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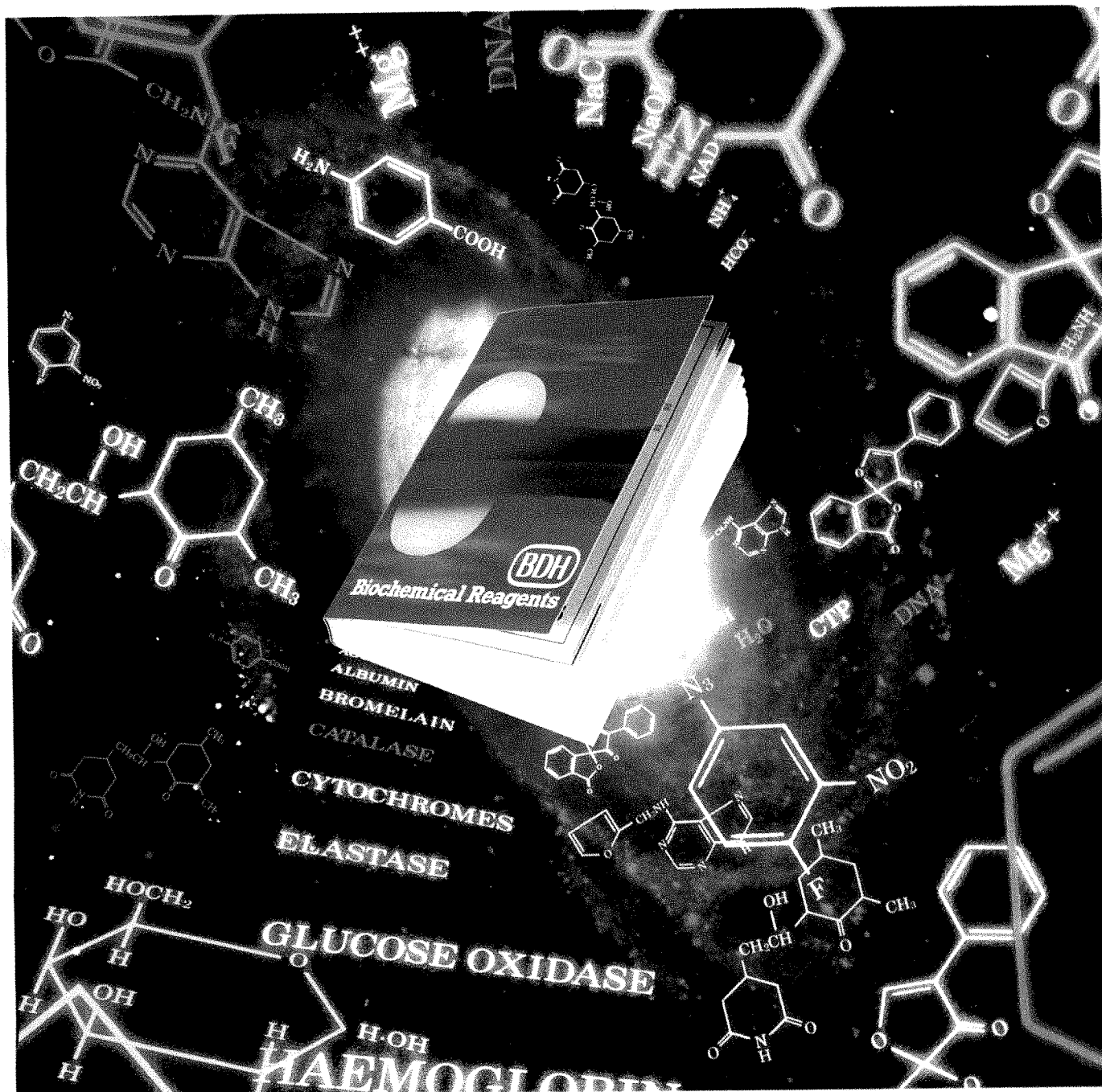
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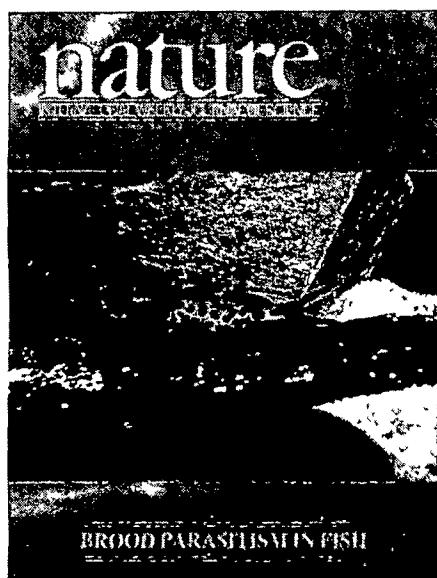
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On page 58 of this issue Sato shows that this mochokid catfish parasitizes the parental care system of the mouthbrooding cichlidae. The catfish exploit the cichlids in much the same way that cuckoos exploit other birds.

OPINION

- Second chance for nuclear power? 1
Chips in big boxes 2

NEWS

- Chernobyl 3
Plan for action
Cuts hurt basic science in France
West German research 4
French science
Ecological warning 5
Biological weapons
Energy research 6
Archaeology
Blood products 7
Good news for lion tamarins
Cameroon disaster 8
Museums
Nuclear power 9
Environmental protection
Sun shines on UN's Kabul adventure

CORRESPONDENCE

- Royal Greenwich Observatory/
Eskimo diets 10

NEWS AND VIEWS

- Have the heavy neutrinos gone? 11
Is there a common design for
cell membrane channels?
Nigel Unwin 12
Elements of an optical engine
Alan Miller 13
Plant ecology: Counting the
costs of rainfall
Peter D Moore 14

- The growing immunoglobulin
gene superfamily 15
Tim Hunkapiller & Leroy Hood
Distinguishing true chirality from
its accidental imitators 16
Alexandra J MacDermott
Physiology: Two glucagon
transducing systems 18
O H Petersen & C Bear
History of isotope geochemistry
and cosmochemistry 19
R Letolle

SCIENTIFIC CORRESPONDENCE

- Minimum-Coulomb-energy
electrostatic configurations 20
S Webb
Haldane's rule back in the news 20
H S Chandra
Radiation and fetal brain development 20
S Zamenhof

BOOK REVIEWS

- The Tender Ship: Governmental
Management of Technological Change
by A M Squires 21
Duncan Davies
The New Genetics and Clinical
Practice, 2nd Edn
by D J Weatherall 21
Robin Carrell
Minerals and Mining in Antarctica:
Science and Technology,
Economics and Politics
by M J de Wit 22
and The Seventh Continent:
Antarctica in a Resource Age
by D Shapley 22
Francis Auburn
Return to the High Valley:
Coming Full Circle
by K E Read 24
Shirley Lindenbaum
Plant Cell Culture Technology
M M Yeoman, ed 24
W A Hughes

CHERNOBYL REPORT

- Coping with the human factor 25
Chronology of a catastrophe 26
Shutting the stable door 28
Tracking radiation release 29
What really went wrong?
Richard Wilson 29

ARTICLES

- Detection of two satellites in the
Cassini division of Saturn's rings 31
E A Marouf & G L Tyler

- Polymer inaccessible volume changes
during opening and closing of a
voltage-dependent ionic channel 36
J Zimmerberg & V A Parsegian

LETTERS TO NATURE

- Cosmic strings, superstrings and
the evolution of the Universe 40
L J Tassie

- Cosmic string, hydrodynamics and
microanisotropies in the
cosmic background radiation 42
S T Chase

- Discovery of organic grains in
comet Halley 44
D T Wickramasinghe
& D A Allen

- Mobilization of cryogenic ice in
outer Solar System satellites 46
D J Stevenson & J I Lunine

- Tropical climatic phase lags
and Earth's precession cycle 48
D A Short & J G Mengel

- Crystallization microstructure
in transparent monotectic alloys 50
W F Kaukler & D O Frazier

- The curvature of Wadati-Benioff
zones and the torsional rigidity
of subducting plates 52
M Bevis

- A deep seismic reflection profile
across the northern North Sea 53
A Beach

- Helium flux in a continental
land area estimated from
³He/⁴He ratio in northern Taiwan 55
Y Sano, H Wakita
& C-W Huang

- A brood parasitic catfish of
mouthbrooding cichlid
fishes in Lake Tanganyika 58
T Sato

- Novel sex differences in linkage
values and meiotic chromosome
behaviour in a marsupial 59
J H Bennett, D L Hayman
& R M Hope

- A molecular link between the bats
of New Zealand and South America 60
E D Pierson, V M Sarich,
J M Lowenstein, M J Daniel
& W E Rainey

Contents continued overleaf

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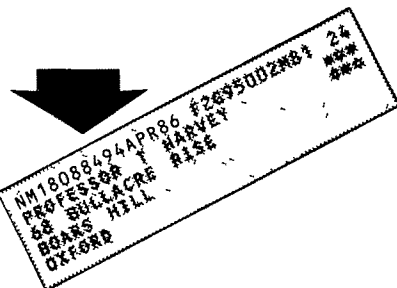
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The mechanism of rectification at the electrotonic motor giant synapse of the crayfish
S W Jaslove & P R Brink 63

Purified dihydropyridine-binding site from skeletal muscle t-tubules is a functional calcium channel
V Flockerzi, H-J Oeken, F Hofmann, D Pelzer, A Cavalié & W Trautwein 66

Activation of two signal-transduction systems in hepatocytes by glucagon
M J O Wakelam, G J Murphy
V J Hruby & M D Houslay 68

In vitro synthesized bacterial outer membrane protein is integrated into bacterial inner membranes but translocated across microsomal membranes
M Watanabe, J F Hunt & G Blobel 71

Striking similarities between antigen receptor J pieces and sequence in the second chain of the murine CD8 antigen
P Johnson & A F Williams 74

Transcripts encoded by a homoeo box gene are restricted to dorsal tissues of *Drosophila* embryos
H J Doyle, K Harding, T Hoey & M Levine 76

Recombinant human TNF induces production of granulocyte-monocyte colony-stimulating factor
R Munker, J Gasson, M Ogawa & H P Koeffler 79

Bovine chromogranin A sequence and distribution of its messenger RNA in endocrine tissues
A Iacangelo, H-U Affolter, L E Eiden, E Herbert & M Grimes 82

Tumour necrosis factor as immunomodulator and mediator of monocyte cytotoxicity induced by itself, γ -interferon and interleukin-1
R Philip & L B Epstein 86

Transposon-dependent mutant phenotypes at the *Notch* locus of *Drosophila*
S Kidd & M W Young 89

Erratum...page 91
Increased levels of myelin basic protein transcripts in virus-induced demyelination
K Kristensson, K V Holmes, C S Duchala, N K Zeller, R A Lazzarini & M Dubois-Dalcq

Corrigendum. page 91
DNA fingerprint analysis in immigration test-cases
W G Hill

NEW ON THE MARKET
From cell motility to flow cytometry 93

EMPLOYMENT

Occupational trends in Britain to 1990
R Pearson 94

MISCELLANY

Books received 92

NATURE CLASSIFIED

Professional appointments —
Research posts — Studentships —
Fellowships — Conferences —
Courses — Seminars — Symposia:
Back Pages

Next week in *Nature*:

- Dynamic phone networks
- New quasar component
- Two-component mantle
- Actinide in marine aerosols
- Bee navigation solved
- Female mate choice in birds
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- New petunia protein
- G proteins and oncogenes

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Contents Volume 1 number 2 (April 1986)

Design, biochemical pharmacology, electrochemistry and tumour biology of anti-tumour anthrapyrazoles H D D SHOWALTER, D W FRY, W R LEOPOLD, J W LOWN, J A PLAMBECK & K RESZKA
DNA-binding abilities of bisguanyldrazones of anthracene-9, 10-dicarboxaldehyde W O FOYE, P S KARNIK, S R SENGUPTA
Effects of structural modifications of anti-tumour antibiotic luzopeptins on cell growth and macromolecule biosynthesis C-H HUANG & S T CROOKE
Correlation between the anti-tumour activity of bivalent and tetravalent platinum complexes and the conformation of their adducts with DNA O VRANA, V BRABEC, V KLEINWACHTER
Conformational flexibility of Ring A in a series of substituted anthracyclines ¹H-NMR and quantum mechanical studies S PENCO, A VIGEVANI, C TOSI, R FUSCO, D BORGHI, F ARCAMONE
Nucleoside analogues 4 Molecular combination of anti-tumour drugs synthesis of 5-fluorouracil seco-nucleosides with CNU residues using aryl-N-nitrosocarbamates J McCORMICK & R S McELHINNEY
Steric constraints for DNA binding and biological activity in the amsacrine series W A DENNY, S J TWIGDEN & B C BAGULEY
Molecular combination of anti-cancer drugs activity of 5-fluorouracil/nitrasourea combination against mouse colon tumours J A DOUBLE, M C BIBBY, J E McCORMICK & R S McELHINNEY
Interrelationships between anti-tumour activity, DNA breakage and DNA binding kinetics for 9-amino-acridine carboxamide anti-tumour agents W A DENNY, I A G ROOS & L P G WAKELIN
DNA sequence-selectivity of three biosynthetic analogues of the quinoxaline antibiotics C M L LOW, K R FOX & M J WARING

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CORAL CLONES

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MARBLE-CAKE MANTLE
MONOCLONALS HELP TRANSPLANTS

How much diversity is there within a reef of coral? On page 109 Jared Diamond comments on some studies that herald the start of a population genetics of coral. (Photograph: R. and V. Taylor, Ardea.)

OPINION

- Towards a mild nuclear winter? 95
- Academics in clover? 96
- Hijacking riposte 96

NEWS

- NASA schedule 97
- Reproductive technology 98
- Australian budget 98
- US science policy 99
- Biotechnology courses 99
- Climatic research 100
- US technology 100
- Particle accelerators 101
- British Association 101
- Murder charge 102
- Indian brain drain 102
- Ice-minus bacteria 103
- Hungarian science 103
- Harvard anniversary 103

CORRESPONDENCE

- Biotechnology guidelines/AIDS 104

NEWS AND VIEWS

- The shortest period binary star 105
- A R King & M G Watson 105
- The bee's celestial compass 106
- R C Hardie 106
- Helium atoms reveal phases 107
- J A Venables 107
- Simple is the best for dynamic routing of telecommunications 108
- Alistair Mees 108
- Clones within a coral reef 109
- Jared M Diamond 109

- A new protein in petunia 110
- J E Varner & G I Cassab 110
- Bone marrow grafts and tolerance 110
- E Donnell Thomas 110
- Is there water in the deep continental crust? 111
- Bruce W D Yardley 111
- Archaeology: A Tuscan mining village 112
- Richard Hodges 112
- G-protein control of inositol phosphate hydrolysis 112
- Bob Michell & Chris Kirk 112
- Obituary: Georgyi Frantsevich Gause 1910-1986 113
- Nikolai N Vorontsov & Jakov M Gall 113
- Geometry: Non-euclidean kaleidoscopes 114
- Ian Stewart 114

SCIENTIFIC CORRESPONDENCE

- AIDS virus and scrapie agent share protein 115
- W A Haseltine & R Partarca 115
- Similarity of *mas* and rhodopsin gene products 116
- H Hayashida, K-I Kuma & T Miyata 116
- Siberian fire as "nuclear winter" guide 116
- R Seitz 116
- Testis size and hermaphroditism 117
- U Mittwoch 117
- Accuracy of testing for Huntington's disease 118
- J F Gusella 118
- Faster than the eye can see 118
- H Stowell 118

BOOK REVIEWS

- The Second Creation: Makers of the Revolution in Twentieth-Century Physics 119
- by R P Crease and C C Mann 119
- Laurie M Brown 119
- Sweet Track to Glastonbury: The Somerset Levels in Prehistory 120
- by B and J Coles 120
- G J Wainwright 120
- Hepatitis B R J Gerety, ed. 120
- A Robert Neurath 120
- Memory, Imprinting, and the Brain 121
- by G Horn 121
- Helmut V B Hirsch 121
- Cooperativity Theory in Biochemistry: Steady-State and Equilibrium Systems by T L Hill 122
- Athel Cornish-Bowden 122
- Implications of a two-component marble-cake mantle 123
- C J Allègre & D L Turcotte 123

ARTICLES

- Polarization vision in bees 128
- S Rossel & R Wehner 128

LETTERS TO NATURE

- Large-scale velocity fields as a test of cosmological models 132
- N Vittorio, R Juszkiewicz & M Davis 132
- A new infrared spectral component of the quasar 3C273 134
- E I Robson, W K Gear, L M J Brown, T J-L Courvoisier, M G Smith, M J Griffin & A Blecha 134

- The flux of meteoroids and orbital space debris striking satellites in low Earth orbit 136
- M R Laurant & D E Brownlee 136

- Heavy nitrogen in Bencubbin — a light-element isotopic anomaly in a stony-iron meteorite 138
- I A Franchi, I P Wright & C T Pillinger 138

- Actinide enrichment in marine aerosols 141
- M I Walker, W A McKay, N J Pattenden & P S Liss 141

- Seismic reflectors, conductivity, water and stress in the continental crust 143
- D I Gough 143

- Large Variscan overthrusts beneath the Paris Basin 144
- M Cazes, A Mascle, X Torrelles, Ch Bois, X Damotte, Ph Matte, X Raoult, V N Pham, A Hirn & X Galdeano 144

- Collapse of the Caledonian orogen and the Old Red Sandstone 147
- K R McClay, M G Norton, P Coney & G H Davis 147

- Palaeoclimatic changes deduced from $^{13}\text{C}/^{12}\text{C}$ and C/N ratios of Karewa lake sediments, India 150
- R V Krishnamurthy, S K Bhattacharya & S Kusumgar 150

- Female pied flycatchers choose territory quality and not male characteristics 152
- R V Alatalo, A Lundberg & C Glynn 152

- Visual orientation in motion-blind flies is an operant behaviour 154
- R Wolf & M Heisenberg 154

Contents continued overleaf

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Elimination of action potentials blocks the structural development of retinogeniculate synapses

R E Kalil, M W Dubin,
G Scott & L A Stark 156

Noradrenaline hyperalgesia is mediated through interaction with sympathetic postganglionic neurone terminals rather than activation of primary afferent nociceptors

J D Levine, Y O Taiwo,
S D Collins & J K Tam 158

A physiological role for titin and nebulin in skeletal muscle

R Horowitz, E S Kempner,
M E Bisher & R J Podolsky 160

Monoclonal antibodies to promote marrow engraftment and tissue graft tolerance

S P Cobbold, G Martin,
S Qin & H Waldmann 164

Isoation of cell lines possessing functional and serological properties resembling those of thymocyte precursors

L O Goodwin, A J D Rocha
& R S Basch 166

Growth restoration of insulin-deficient diabetic rats by recombinant human insulin-like growth factor I

E Scheiwiller, H P Guler,
J Merryweather, C Scandella
W Maerki, J Zapf & E R Froesch 169

Growth factor-like action of phosphatidic acid

W H Moolenaar, W Kruijer,
B C Tilly, I Verlaan,
A J Biermann & S W de Laat 171

Normal p21^{N^{ras}} couples bombesin and other growth factor receptors to inositol phosphate production

M J O Wakelam, S A Davies,
M D Houslay, I McKay,
C J Marshall & A Hall 173

Selective proteolysis defines two DNA binding domains in yeast transcription factor τ

N Marzouki, S Camier, A Ruet,
A Moenne & A Sentenac 176

A gene encoding a novel glycine-rich structural protein of petunia

C M Condit & R B Meagher 178

Endogenous ADP-ribosylation of G_s subunit and autonomous regulation of adenylate cyclase

C Jacquemin, H Thibout,
B Lambert & C Correze 182

Erratum...page 184

The crystal structure of d(GGATGGGAG): an essential part of the binding site for transcription factor IIIA
M McCall, T Brown,
W N Hunter & O Kennard

MATTERS ARISING

The statistics of quasar pairs

P A Shaver
Reply: G A Burbidge,
J V Narlikar & A Hewitt 185

Homology between IgE-binding factor gene and endogenous retroviruses

S Ymer & I G Young 186

PRODUCT REVIEW

Cassette mutagenesis shows its strength

J H Richards 187
Communing with Nature 188

NATURE CLASSIFIED

**Professional appointments —
Research posts — Studentships —
Fellowships — Conferences —
Courses — Seminars — Symposia:**

Back Pages

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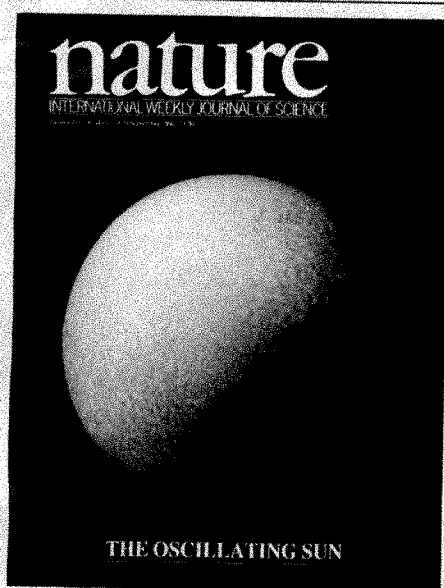
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NATURE VOL. 323 18 SEPTEMBER 1986



A velocity image of the Sun, made using the Doppler effect. Bright is approaching, dark receding, with the total range in velocity being about 3 km s^{-1} . The gradient shows the solar rotation, and the mottling outlines numerous convection cells called the super-granulation. Thousands of these images are analysed in helioseismology, showing millions of the Sun's oscillation modes. The excitation of such oscillations by turbulence is discussed on p.235.

OPINION

- Towards a global understanding** 189
Strategic arms meeting 190
Wall street jitters

NEWS

- Acid rain in Norway** 191
Newton to Rutherford in oils 192
US budget
Rain forest preservation 193
Japan says yes
Indian visas 194
Soviet scientist
New comet
Australian uranium 195
German space plane
New ceramics 196
Resignation provokes criticism
French nuclear accident
Galileo Jupiter probe 197
Industrial biotechnology

CORRESPONDENCE

- Tooth decay/Aspirin/Space power/**
Edgar Allan Poe 198

NEWS AND VIEWS

- Helices with optical activity**
John Maddox 199
Is lead pollution of the atmosphere
a global problem?
David A Peel 200

Visions in humans and computers

Oliver Braddick 201

From multi-branched snowflakes to precious minerals

Herbert E Huppert 202

Lectin biochemistry: New way of protein maturation

Nathan Sharon & Halina Lis 203

Classical mechanics: Tops that like to spin one way

Robert Walgate 204

Neurobiology: dopamine receptor disputes

J M Palacios 205

Improving prospects for a schistosomiasis vaccine

S R Smithers 205

Geophysics: Friction on the San Andreas fault

Roger Anderson 206

Biological activity and seabed sediment structure

P S Meadows 207

SCIENTIFIC CORRESPONDENCE

Dragon's exhalations give clue to Chernobyl

R H Flowers 208

Decontamination puts meat in a pickle

R Wahl & E Kallee 208

Body in the bog but no DNA

M A Hughes & D S Jones 208

Out of Africa—through a genetic bottleneck

D M Hillis 208

BOOK REVIEWS

The gift of Taungs—three books on palaeoanthropology

Andrew Hill 209

In the Company of Animals:

A Study of Human—Animal

Relationships

by J Serpell

Juliet Clutton-Brock 210

Physics of the Sun

P A Sturrock et al., eds

Eugene N Parker 210

A Colour Atlas of Insect Tissues via the Flea

by M Rothschild et al.

Nancy J Lane

Homi Jehangir Bhabha: Collected Scientific Papers

B V Sreekantan et al., eds

Rudolf Peierls

Scanning Electron Microscopy:

Physics of Image Formation

and Microanalysis

by L Reimer

V E Cosslett, 212

COMMENTARY

National security and the post-war science establishment in the United States

A Hunter Dupree 213

REVIEW ARTICLE

Role of the cerebellum in the visual guidance of movement

J F Stein 217

ARTICLES

Lead concentration changes in Antarctic ice during the Wisconsin/Holocene transition

C F Boutron & C C Patterson 222

Structure of the receptor for platelet-derived growth factor helps define a family of closely related growth factor receptors

Y Yarden, J A Escobedo, W-J Kuang, T L Yang-Feng, T O Daniel, P M Tremble, E Y Chen, M E Ando, R N Harkins, U Francke, V A Fried, A Ullrich & L T Williams 226

LETTERS TO NATURE

Infrared point sources aligned with the Sgr A* non-thermal radio source

W A Stein & W J Forrest 232

New determination of the angular diameter of Sirius

J Davis & W J Tango 234

The excitation and damping of solar oscillations

K G Libbrecht, B D Popp, J M Kaufman & M J Penn 235

Rossby autosoliton and stationary model of the jovian Great Red Spot

S V Antipov, M V Nezlin, E N Snezhkin & A S Trubnikov 238

Product yield of magnetic-field-dependent photochemical reaction modulated by electron spin resonance

M Okazaki & T Shiga 240

Estimation of oceanic eddy transports from satellite altimetry

G Holloway 243

Empirical relation between sulphur dioxide emissions and acid deposition derived from monthly data

C B Epstein & M Oppenheimer 245

Contents continued overleaf

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Late-glacial climatic oscillation in Atlantic Canada equivalent to the Allerød/younger Dryas event
R J Mott, D R Grant,
R Stea & S Occhietti 247

In situ studies of megafaunal mounds indicate rapid sediment turnover and community response at the deep-sea floor
C R Smith, P A Jumars
& D J DeMaster 251

End-Cretaceous devastation of terrestrial flora in the boreal Far East
T Saito, T Yamanoi & K Kaiho 253

Spatial heterogeneity: evolved behaviour or mathematical artefact?
J A Downing 255

Inhibition of microbial activity in marine sediments by a bromophenol from a hemichordate
G M King 257

Immunization of Aotus monkeys with recombinant proteins of an erythrocyte surface antigen of Plasmodium falciparum
W E Collins, R F Anders,
M Pappaioanou, G H Campbell,
G V Brown, D J Kemp,
R L Coppel, J C Skinner,
P M Andrysiak, J M Favaloro,
L M Corcoran, J R Broderson,
G F Mitchell & C C Campbell 259

Two antigen-independent adhesion pathways used by human cytotoxic T-cell clones
S Shaw, G E G Luce,
R Quinones, R E Gress,
T A Springer & M E Sanders 262

Substrate phosphoprotein availability regulates eclosion hormone sensitivity in an insect CNS
D B Morton & J W Truman 264

Localization of D-2 dopamine receptors to intrinsic striatal neurones by quantitative autoradiography
J M Trugman, W A Geary II
& G F Wooten 267

Single-channel and whole-cell recordings of mitogen-regulated inward currents in human cloned helper T lymphocytes
M Kuno, J Goronzy,
C M Weyand & P Gardner 269

Opposite effects of cyclic GMP and cyclic AMP on Ca²⁺ current in single heart cells
H C Hartzell & R Fischmeister 273

Weak acids may act as teratogens by accumulating in the basic milieu of the early mammalian embryo
H Nau & W J Scott Jr 276

Maternal control of Drosophila segmentation gene expression
S B Carroll, G M Winslow,
T Schüpbach & M P Scott 278

NATURE CLASSIFIED

**Professional appointments —
Research posts — Studentships —
Fellowships — Conferences —
Courses — Seminars — Symposia:**
Back Pages

Next week in Nature:

- Hubble's constant from gravity waves
- Solar oscillations
- Quasiperiodic structures
- Earthquakes recorded stratigraphically
- Deep-ocean mixing
- Australopithecine dentistry
- Glutamine synthetase subunits
- Suspended clay deters zooplankton
- Towards AIDS vaccine
- A mystery object
- New journals review

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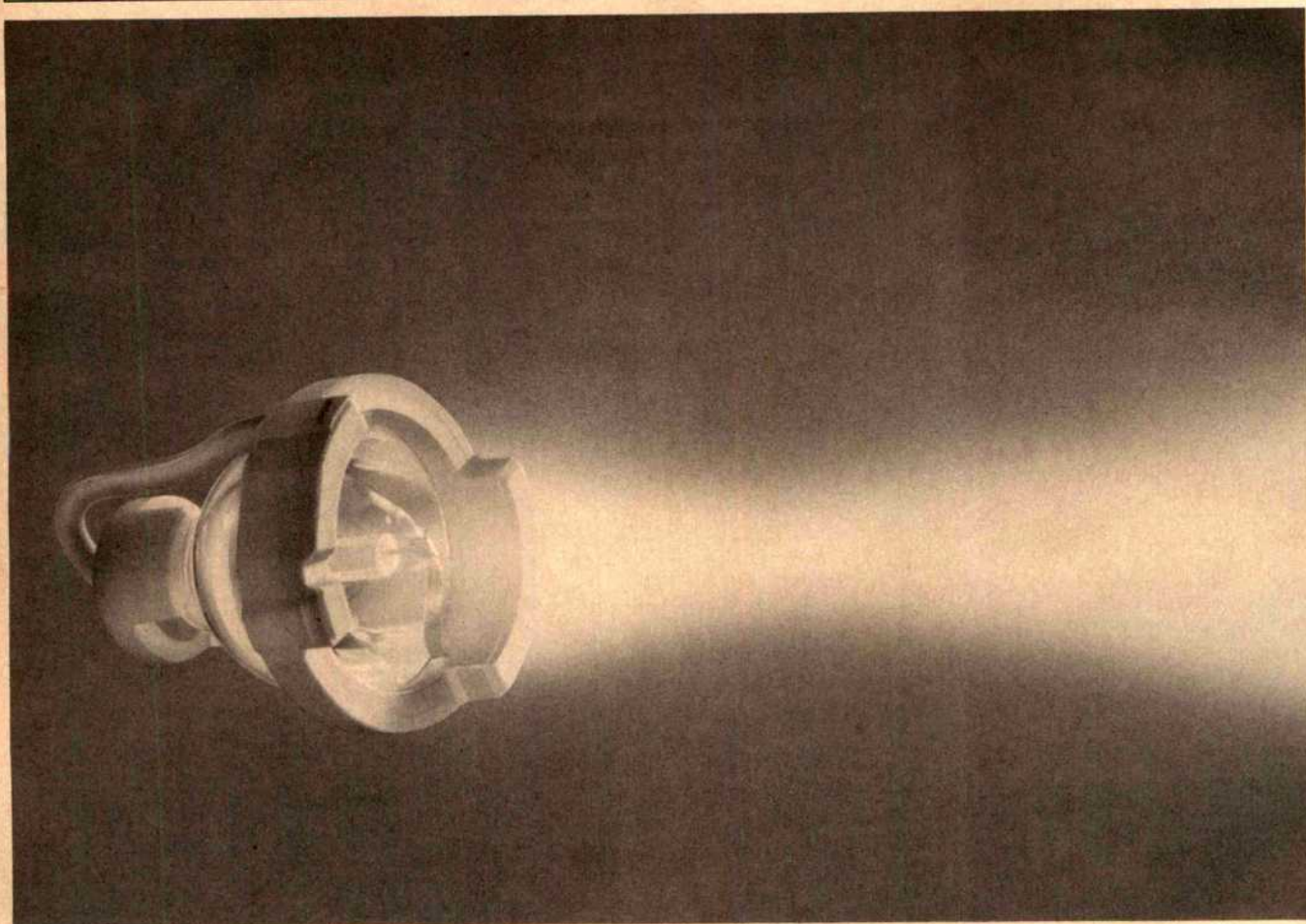
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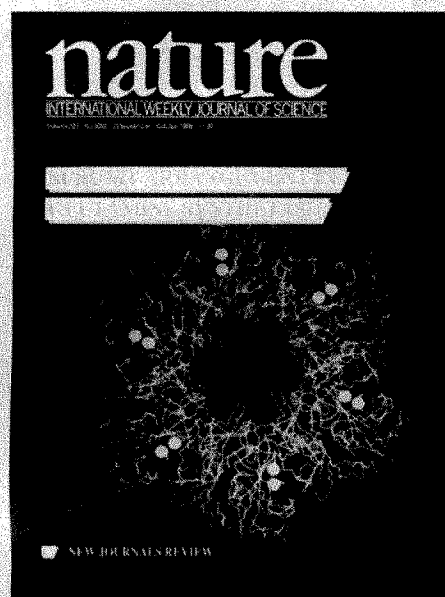
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The glutamine synthetase enzyme from *Salmonella typhimurium*, an important enzyme in bacterial nitrogen metabolism. The 12 protein subunits are shown as line segments connecting α -carbon atoms of sequential amino acids. The 6 green subunits are above the 6 orange subunits. The article appears on page 304.

OPINION

- Keeping narcotic drugs at bay 281
Trade makes sense 282
Fireworks at Yale

NEWS

- AIDS 283
Arms control 284
Japanese grants 284
India's space programme 285
US drug tests 286
Stratospheric ozone 286
British research funds 287
Solar power 287
Albanian soft option 288
Chemical warfare 288
Biotechnology patents 289
Crafoord and Lasker prizes 289

CORRESPONDENCE

- Apartheid objectors/Colonial legacy/Miracles 290

NEWS AND VIEWS

- Is megasequencing madness? 291
Peter Newmark 291
Virtuoso design of drugs 292
Solomon H Snyder 292

- Five-fold symmetry:
Disorder among the atoms 293
Alan L MacKay
Secondary messenger dualism in
neuromodulation and memory 294
Michael Berridge
Glueball sightings premature 295
Frank Close
Magnetic reversals:
From the core or the skies? 296
J A Jacobs
Mantle mixing still a mystery 297
Dan McKenzie
Stunning whales and deaf squids 298
Michael Alan Taylor
Viral RNA in mitochondria? 299
David M Lonsdale

—SCIENTIFIC CORRESPONDENCE—

- Mystery object amid the
chromosomes 300
J Wolstenholme, I Harlow,
G Clarke, H Sheridan,
J Jonasson,
M Crocker, & H Matthews
Prospects for rabies control by
vaccination 300
S M Smith
Body temperature and the specific
heat of water 300
J Paul
FRP is follicle regulatory protein 300
G S DiZerega

NEW JOURNALS

- Altered points of reference 359
Mary Holmes
This issue contains reviews of a selection of new journals which appeared between June 1984 and May 1985. The reviews being on p.361, with an introduction and index on p.360.

ARTICLES

- High-latitude salinity effects and
interhemispheric thermohaline
circulations 301
F Bryan
Novel subunit-subunit interactions
in the structure
of glutamine synthetase 304
J Almassy, C A Janson, R Hamlin,
N-H Xuong & D Eisenberg

—LETTERS TO NATURE—

- Determining the Hubble constant
from gravitational wave
observations 310
B J Schutz

- Detection of hydrogen cyanide
emission from the peculiar
oxygen-rich evolved star
IRC + 10420 311
P R Jewell, L E Snyder
& M S Schenewerk

- Diffraction of pattern simulations
of quasiperiodic structures 313
K M Knowles
& W M Stobbs

- Quantitative bounds on the size
spectrum of isotopic heterogeneity
within the mantle 317
M Gurnis

- Earthquakes recorded
stratigraphically on
carbonate platforms 320
J L Cisne

- A deliberate tracer experiment in
Santa Monica Basin 322
J R Ledwell, A J Watson
& W S Broecker

- Aqueous aluminium chemistry
response to episodic increases
in discharge 324
T J Sullivan, N Christophersen,
I P Muniz, H M Seip
& P D Sullivan

- Dental development in
Australopithecus and
early *Homo* 327
B Holly Smith

- Suspended clay concentration
controlled by filter-feeding
zooplankton in a tropical reservoir 330
M Z Gliwicz

- Two polyphosphatidylinositide
metabolites control two K^+
currents in a neuronal cell 333
H Higashida & D A Brown

- The oligodendrocyte type-2
astrocyte cell lineage is
specialized for myelination 335
C ffrench-Constant
& M C Raff

- Identity of differentiation inducing
factor and tumour necrosis factor 338
K Takeda, S Iwamoto,
H Sugimoto, T Takuma, N Kawatani,
M Noda, A Masaki,
H Morise, H Arimura
& K Konno

Contents continued overleaf

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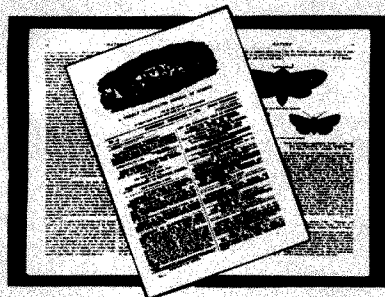
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Phenotypic changes induced by a mutated *ras* gene during the development of

Dictyostelium transformants

C D Reymond, R H Gomer,
W Nellen, A Theibert,
P Devreotes & R A Firtel

340

T-cell responses to human AIDS virus in macaques immunized with recombinant vaccinia viruses

J M Zarlign, W Morton,
P A Moran, J McClure,
S G Kosowski & S-L Hu

344

Isolation of complementary DNA clones encoding the human lymphocyte glycoprotein T1/Leu-1

N H Jones, M L Clabby,
D P Dialynas, H-J S Huang,
L A Herzenberg
& J L Strominger

346

Non-enzymatic cleavage and ligation of RNAs complementary to a plant virus satellite RNA

J M Buzayan, W L Gerlach
& G Bruening

349

A cyclic AMP- and phorbol ester-inducible DNA element

M Comb, N C Birnberg,
A Seasholtz, E Herbert
& H M Goodman

353

Cumulative effect of intragenic amino-acid replacements on the thermostability of a protein

M Matsumura, S Yasumura
& S Aiba

356

MISCELLANY

100 years ago

296

Books received

380

NATURE CLASSIFIED

Professional appointments —

Research posts — Studentships —

Fellowships — Conferences —

Courses — Seminars — Symposia:

Back Pages

Next week in *Nature*:

- Muscarinic acetylcholine receptor sequence
- Nucleon structure
- Viscous fingers in nematic liquid crystals
- Structure of catalyst particles
- Non-newtonian phytoplankton
- Actin-binding domain of gelsolin
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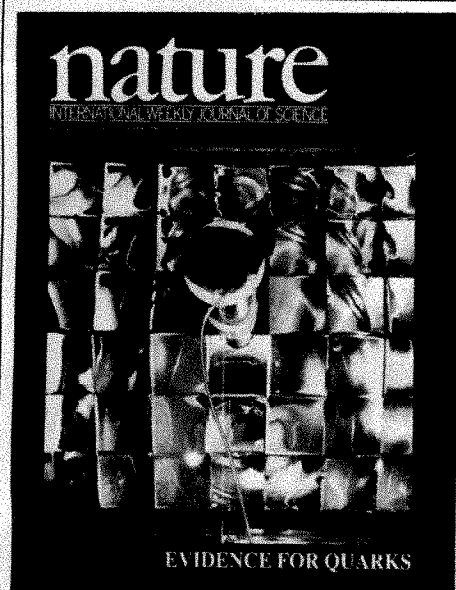
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OPINION

- Can British universities recover?** 381
Ideal undermines good
Computers by halves 382

NEWS

- British universities** 383
Strategic exports
AIDS in California 384
AIDS in Japan
In vitro fertilization 385
Scientific collaboration
Pact for nuclear accidents 386
French science budget
New high-speed aircraft
Biotechnology 387
Chernobyl fallout
Voyager at Neptune 388
Sea defence line
Research integration 389
Oceans and atmosphere
Mutation screening

CORRESPONDENCE

- Dinosaur prints/Vegetarianism and greenhouse effect/Damadian** 390

NEWS AND VIEWS

- How to make molecules into atoms** 391
Earth sciences: Deep reflections on the Moho
Penny Barton 392

Biochemistry: Evolutionary economics

Roger H Pain 393

Neurobiology: Routes for development

R W Guillery 394

Dizzily deformed dysprosium

J D Garrett 395

Distinctions in acetylcholine receptor activity

Edward Hulme & Nigel Birdsall 396

Mathematics: Singular flying pancakes

Ian Stewart 397

Predicting fruitfly guild sizes

John H Lawton 398

—SCIENTIFIC CORRESPONDENCE—

Core fragments in Chernobyl fallout

J van der Veen, A van der Wijk, 399
 W G Mook & R J de Meijer

Microtubule assembly in the axon

J R Bamberg, D Bray 400
 & K Chapman

Biochemical basis of cystic fibrosis

M A McPherson, R L Dormer, 400
 M C Goodchild & J A Dodge

Silver foils gravitational principles

M Pyke 400

BOOK REVIEWS

Molecular Cell Biology

by J Darnell, H Lodish 401
 and D Baltimore

Joseph G Gall

401

Atmospheric Chemistry:

Fundamentals and Experimental 402
 Techniques

by B J Finlayson-Pitts and J N Pitts, Jr 402

Richard P Wayne

To Utopia and Back: The Search for Life in the Solar System

by N H Horowitz 402

James Trefil

The Psychology of Eating and Drinking

by A W Logue 403

Stuart Sutherland

Functional Vertebrate Morphology

M Hildebrand et al., eds 404

Kathleen K Smith

Physics of Comets

by K S Krishna Swamy 404

John C Brandt

REVIEW ARTICLE

The structure of the nucleon from deep inelastic lepton scattering and the nature of the strong interaction

T Sloan 405

ARTICLES

Cloning, sequencing and expression of complementary DNA encoding the muscarinic acetylcholine receptor

T Kubo, K Fukuda, A Mikami, 411
 A Maeda, H Takahashi, M Mishina, T Haga, K Haga, A Ichiyama, K Kangawa, M Kojima, H Matsuo, T Hirose & S Numa

LETTERS TO NATURE

An emission-line object in the core of M15

P A Charles, D C Jones & T Naylor 417

Particle acceleration in the hotspot of the jet of quasar 3C273

K Meisenheimer & A F Heavens 419

Companion-star beam steering of high-energy particles from Hercules X-1

P W Gorham & J G Learned 422

Transitions of viscous fingering patterns in nematic liquid crystals

A Buka, J Kertész & T Vicsek 424

Radio acoustic measurement of temperature profile in the troposphere and stratosphere

N Matuura, Y Masuda, 426
 H Inuki, S Kato, S Fukao, T Sato & T Tsuda

Atomic structure of ultrafine catalyst particles resolved with a 200-keV transmission electron microscope

D A Jefferson, J M Thomas, 428
 G R Millward, K Tsuno, A Harriman & R D Brydson

Energy conversion catalysis using semiconducting transition metal cluster compounds

N Alonso Vante & H Tributsch 431

Frontal surveys with a towed profiling conductivity/temperature/depth measurement package (SeaSoar)

R Pollard 433

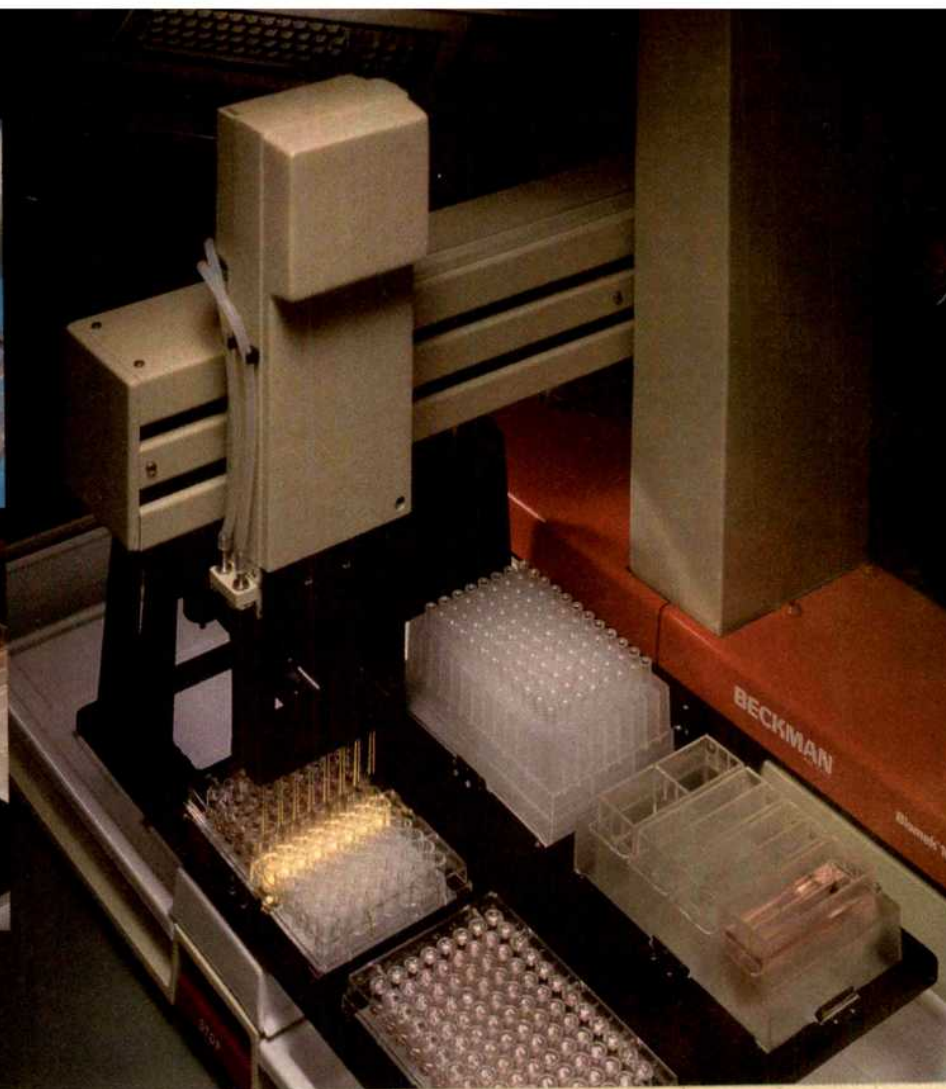
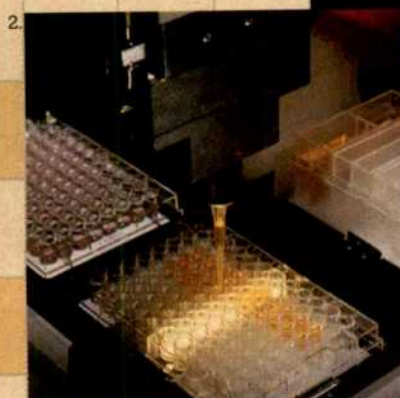
Oceanographic implications of non-newtonian properties found in phytoplankton cultures

I R Jenkinson 435

Stomata and sterome in early land plants

D Edwards, U Fanning 438
 & J B Richardson

Contents continued overleaf



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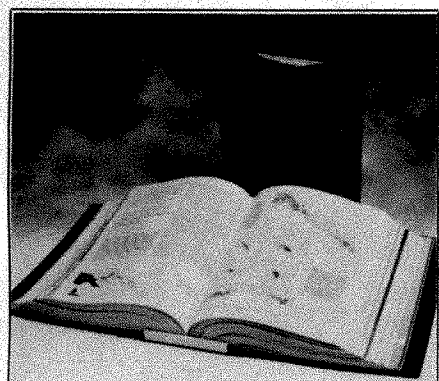
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Two identified afferent neurones entrain a central locomotor rhythm generator

K T Sillar, P Skorupski,
R C Elson & B M H Bush 440

Schistosoma mansoni shares a protective oligosaccharide epitope with freshwater and marine snails
C Dissous, J M Grzych
& A Capron 443

Germ-line transmission of genes introduced into cultured pluripotent cells by retroviral vector

E Robertson, A Bradley,
M Kuehn & M Evans 445

A family of related ATP-binding subunits coupled to many distinct biological processes in bacteria

C F Higgins, I D Hiles,
G P C Salmond, D R Gill,
J A Downie, I J Evans,
I B Holland, L Gray, S D Buckel,
A W Bell & M A Hermodson 448

Domainal evolution of a prokaryotic DNA repair protein and its relationship to active-transport proteins

R F Doolittle, M S Johnson,
I Husain, B Van Houten,
D C Thomas & A Sancar 451

Mapping of the class II region of the human major histocompatibility complex by pulsed-field gel electrophoresis

D A Hardy, J I Bell, E O Long,
T Lindsten & H O McDevitt 453

Plasma and cytoplasmic gelsolins are encoded by a single gene and contain a duplicated actin-binding domain

D J Kwiatkowski, T P Stossel,
S H Orkin, J E Mole,
H R Colten & H L Yin 455

Bending of promoter DNA on binding of heat shock transcription factor

D J Shuey & C S Parker 459

Cloning and sequence analysis of cDNA for bovine carboxypeptidase E

L D Fricker, C J Evans,
F S Esch & E Herbert 461

A novel selective broad-spectrum anti-DNA virus agent

E De Clercq, A Holy,
I Rosenberg, T Sakuma,
J Balzarini & P C Maudgal 464

Suppression of mouse viraemia and retroviral disease

by 3'-azido-3'-deoxythymidine
R M Ruprecht, L G O'Brien,
L D Rossoni
& S Nusinoff-Lehrman 467

MATTERS ARISING

Core formation and Earth's late accretionary history

J H Jones & M J Drake
Reply: J W Morgan 470

Age interpolation

R Ehrlich & I Lerche
Reply: C Badgley, L Tauxe
& F L Bookstein 471

Are enigmatic markings in Adelaidean of Flinders Ranges fossil ice-tracks?

R J F Jenkins 472

NEW ON THE MARKET

Handling cells, spills and refills 473

EMPLOYMENT

So few women in engineering
R Pearson 474

NATURE CLASSIFIED

Professional appointments —
Research posts — Studentships —
Fellowships — Conferences —
Courses — Seminars — Symposia:
Back Pages

Next week in Nature:

- Multiple quasars
- Shuttle glow
- Geotraverse of Tibet
- Fossil amino acids
- Plant gene enhancer/silencer
- Hepatitis virus sequences

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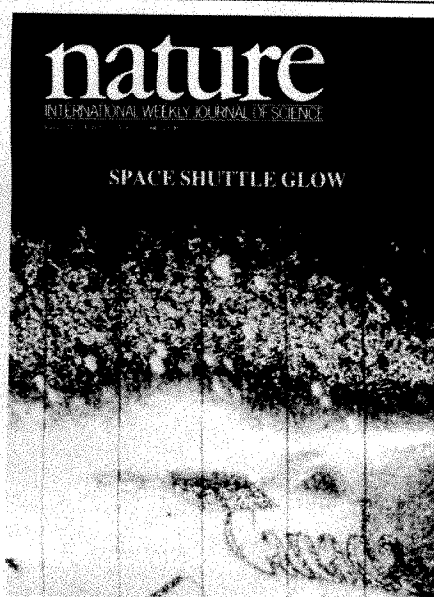
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OPINION

- Does deregulation work? 475
Japanese distinction 476
Death of a submarine

NEWS

- US semiconductors 477
Sino-British collaboration in Tibet
Soviet Union 478
US embargo
Europe 479
Plagiarism
Genetic manipulation 480
Netherlands research
Occupational radiation 481
Space shuttle
US-Soviet space 482
Space facility
Britain in space
Shroud to be dated
US semiconductors 483
Soviet Union

CORRESPONDENCE

- Cost of RGO move to Cambridge/
How to verify/Criteria of science 484

NEWS AND VIEWS

- Calculating melting temperatures 485
Cognition: Parallel distributed
processing
Stuart Sutherland 486
Antiprotons tickle nuclei
CJ Batty 487

- Are we losing the war on cancer?
Marie M Cohen & Jared M Diamond 488
Retroviral vaccines: How close
is C to D?

- Jerome E Groopman 489

- Black hole origins of active nuclei
challenged in Armenia

- Martin Ward & Ian Robson 490

- Fast glacier flow: A soft bed is
not the whole answer

- Gordon de Q Robin 490

- Ocean Drilling Program: Coring
the crust and the mantle

- Leg 109 shipboard scientific party 492

- Pharmacological treatment of
central nervous system injury

- Bernhard A Sabel & Donald G Stein 493

- New medical and scientific
uses of the leech

- Charles Lent 494

SCIENTIFIC CORRESPONDENCE

- Human immunodeficiency virus
an unacceptable term

- P Brandtzaeg 495

- Screwworm eradication is
what it seems

- E S Krafur, H Townson,
G Davidson & C F Curtis 495

- UK release of genetically
marked virus

- D H L Bishop 496

BOOK REVIEWS

- Gavagai! Or the Future History of the
Animal Language Controversy

- by D Premack and

- Silent Partners: The Legacy of the
Ape Language Experiments

- by E Linden

- E W Menzel Jr 497

- Contemporary Classics in the Life
Sciences

- J T Barrett, ed.

- F J Bollum 498

- John Ray: Naturalist

- by C E Raven

- David E Allen 499

- Amorphous Silicon Solar Cells

- by K Takahashi and M Konagai

- G F J Garlick 500

- Group Structure of Gauge Theories

- by L O'Rai feartaigh

- Paul Langacker 500

ARTICLES

- Preliminary conclusions of the Royal
Society and Academia Sinica 1985

- geotraverse of Tibet

- C Chang, N Chen, M P Coward,

- W Deng, J F Dewey,

- A Gansser, N B W Harris,
C Jin, W S F Kidd,
M R Leeder, H Li, J Lin,
C Liu, H Mei, P Molnar,
Y Pan, Y Pan, J A Pearce,
R M Shackleton, A B Smith,
Y Sun, M Ward,
D R Watts, J Xu, R Xu,
J Yin & Y Zhang 501

- Structure, sequence and expression of
the hepatitis delta (δ) viral genome
K-S Wang, Q-L Choo, A J Weiner,
J-H Ou, R C Najarian, R M Thayer,
G T Mullenbach, K J Denniston,
J L Gerin & M Houghton 508

LETTERS TO NATURE

- Double clusters and gravitational
lenses
C S Crawford, A C Fabian
& M J Rees 514

- Multiple quasars for multiple images
J N Bahcall, N A Bahcall
& D P Schneider 515

- Simulating the sunspot cycle
R N Bracewell 516

- The effect of temperature on
shuttle glow
G R Swenson, S B Mende
& E J Llewellyn 519

- Isotopic enrichment by electron
exchange
G R Stevenson, M P Espe,
R C Reiter & D J Lovett 522

- Evaporative cooling of the western
equatorial Pacific Ocean by
anomalous winds
G Meyers, J R Donguy & R K Reed 523

- Coherent response of Arabian Sea
upwelling and pollen transport to
late Quaternary monsoonal winds
W L Prell & E Van Campo 526

- Humic macromolecule interlayering
in nontronite through
interaction with phenol monomers
M C Wang & P M Huang 529

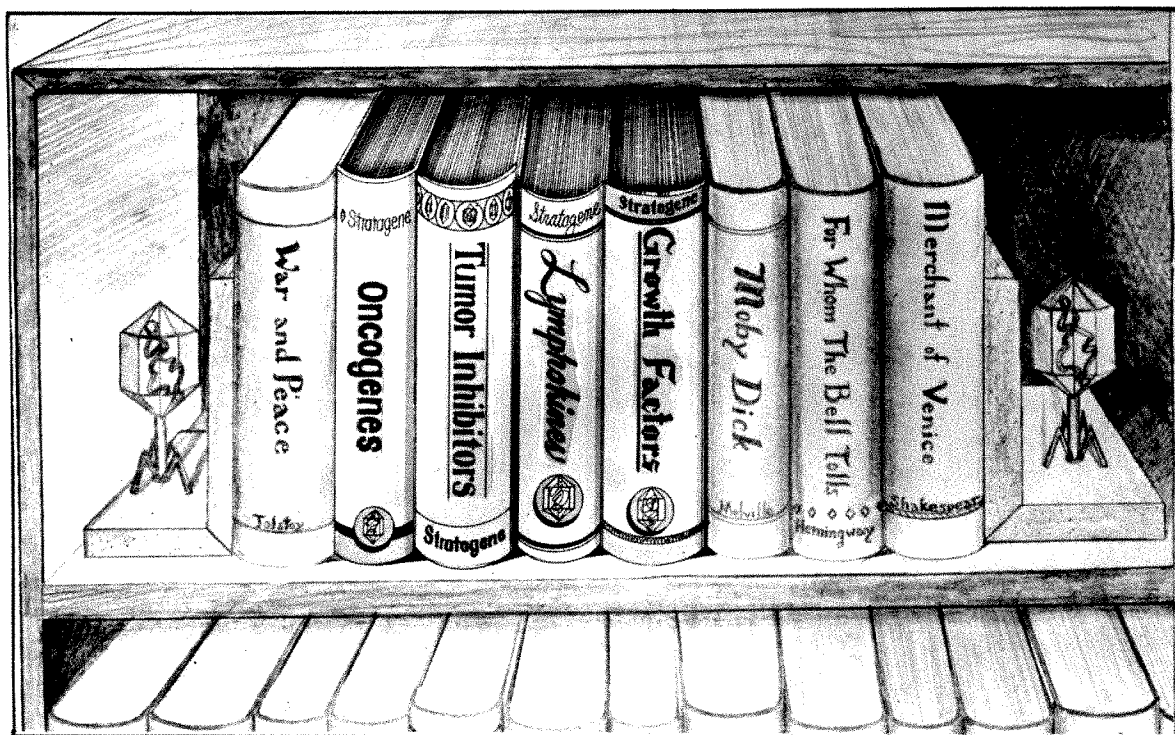
- Stable isotope evaluation of the
origins of amino acids in fossils
M H Engel & S A Macko 531

- Learning representations by
back-propagating errors
D E Rumelhart, G E Hinton
& R J Williams 533

Contents continued overleaf

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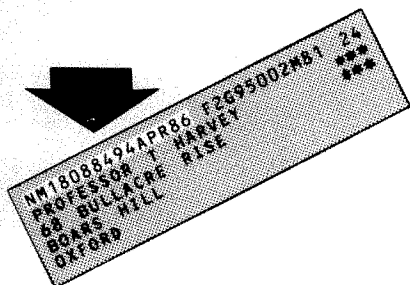
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Bilateral amblyopia after a short period of reverse occlusion in kittens
K M Murphy & D E Mitchell 536

Chemotropic effect of specific target epithelium in the developing mammalian nervous system
A G S Lumsden & A M Davies 538

A novel family of human major histocompatibility complex-related genes not mapping to chromosome 6
F Calabi & C Milstein 540

Cell-type specific protein binding to the enhancer of simian virus 40 in nucleus extracts
I Davidson, C Fromental, P Augereau, A Wildeman, M Zenke & P Chambon 544

Interaction of cell-type-specific nuclear proteins with immunoglobulin V_H promoter-region sequences
N F Landolfi, J D Capra & P W Tucker 548

Light-inducible and tissue-specific pea *lhcp* gene expression involves an upstream element combining enhancer- and silencer-like properties
J Simpson, J Schell, M Van Montagu & L Herrera-Estrella 551

Phorbol ester induces the transcriptional stimulatory activity of the SV40 enhancer
R J Imbra & M Karin 555

The hepatitis delta (δ) virus possesses a circular RNA
A Kos, R Dijkema, A C Arnberg, P H van der Meide & H Schellekens 558

The nuclear lamina is a meshwork of intermediate-type filaments
U Aebi, J Cohn, L Buhle & L Gerace 560

***Rhizobium nod* genes are involved in inducing an early nodulin gene**
F Govers, M Moerman, J A Downie, P Hooykaas, H J Franssen, J Louwerse, A van Kammen & T Bisseling 564

MISCELLANY

100 years ago 491

NATURE CLASSIFIED

Professional appointments —
Research posts — Studentships —
Fellowships — Conferences —
Courses — Seminars — Symposia:

Back Pages

Next week in *Nature*:

- Are superstrings real?
- Lightning on Uranus
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OPINION

For details see 567

NEWS

For details see 567

CORRESPONDENCE

Grading of universities/
Defining Darwinism/
Dioxin risk 576

NEWS AND VIEWS

Editorial 577
Questions of sex and colour
John D Mollon 578
Solar neutrinos may hold the key
Lincoln Wolfenstein 579
Contentious issues in sexual selection
Linda Partridge and Paul Harvey 580
Response to an Archaean continental
collision
Mike Bickle 581
Malignant tumours generated
by recessive mutations
Henry Harris 582

First glimpse of the gene for
Duchenne muscular dystrophy
Peter N Goodfellow 583
Anaesthesia: Models of consciousness
Keith W Miller 584

SCIENTIFIC CORRESPONDENCE

How do bacteria acquire
plant genes?
A G Brownless 585
Caught in a trap
A Ashkin,
J E Bjorkholm, S Chu 585
Cancer risk assessments
in light of Chernobyl
R R Jones 585
Declining support for Imanishi
O Sakura, T Sawaguchi, H Kudo,
S Yoshikubo 586
The number of glucagon
receptors and the MHC
R P Erickson 586
Monoclonals and
marrow transplant
H Waldmann, S P Cobbold 586

BOOK REVIEWS

Ecological Imperialism: The
Biological Expansion of
Europe, 900-1900
by A W Crosby 587
Roy Porter
The Forces of Nature, 2nd Edn
by P C W Davies 588
Frank Close
Protein Secretion: A Critical Analysis
of the Vesicle Model
by S S Rothman 588
M S Bretscher
Molecular Cytology
by J Brachet 589
David M Prescott
The Beauty of Fractals: Images
of Complex Dynamical Systems
by H-O Peitgen and P H Richter 590
Michael Berry

COMMENTARY

Is Britain spending
enough on science?
J Irvine & B R Martin 591

REVIEW ARTICLE

The superstring: theory of
everything, or of nothing?
J Ellis 595

ARTICLES

Non-explosive silicic volcanism
J C Eichelberger, C R Carrigan,
H R Westrich & R H Price 598

LETTERS TO NATURE

Variable radio source GT0116 +
622 is a possible counterpart to Cas γ-1
P C Gregory, N Duric,
A Reid, J Picha,
T Stevenson & A R Taylor 602

Magnetic field corrections to
solar oscillation frequencies
B Roberts & W R Campbell 603

Radio detection of uranian
lightning by Voyager 2
P Zarka & B M Pedersen 605

Quantum jumps and atomic
cryptograms
P L Knight, R Loudon
& D T Pegg 608

Do climatic attractors exist?
P Grassberger 609

Surface topography of (100)-type
electro-faceted platinum from
scanning tunnelling microscopy
and electrochemistry
J Gómez, L Vázquez, A M Baró,
N Garcia, C L Perdriel,
W E Triaca & A J Arvia 612

Room-temperature ionic liquids as
solvents for electronic absorption
spectroscopy of halide complexes
D Appleby, C L Hussey,
K R Seddon & J E Turp 614

Basal reversals in layered intrusions
are evidence for emplacement of
compositionally stratified magma
J R Wilson & O Engell-Sørensen 616

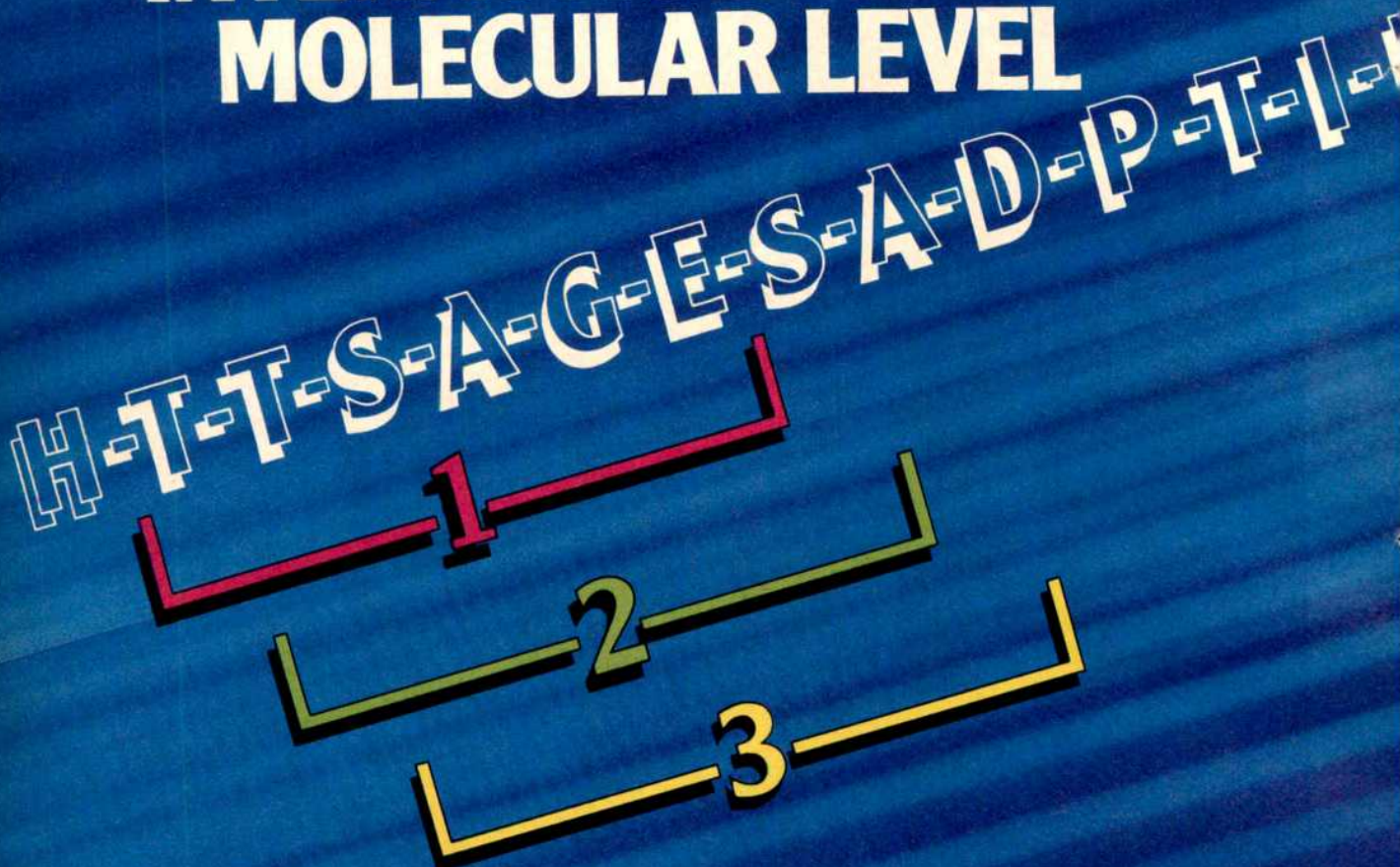
Pleistocene occupation in the
south-east Queensland
coastal region
R Neal & E Stock 618

Evolution of the ermine moth
pheromone tetradecyl acetate
C Löfstedt, W M Herrebout
& J-W Du 621

Polymorphism of the long-
wavelength
cone in normal
human colour vision
J Neitz & G H Jacobs 623

Contents continued overleaf

ANTIGEN-ANTIBODY INTERACTIONS AT THE MOLECULAR LEVEL



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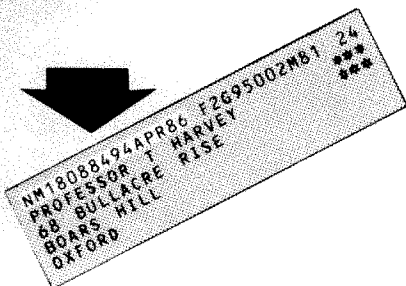
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Cholinergic neuropil of the striatum observes striosomal boundaries

A M Graybiel,
R W Baughman & F Eckenstein 625

Voltage dependence of Na translocation by the Na/K pump

M Nakao & D C Gadsby 628

Ammonia orients cell masses and speeds up aggregating cells of slime moulds

J T Bonner,
H B Suthers & G M Odell 630

Flavones induce expression of nodulation genes in *Rhizobium*

J W Redmond, M Batley,
M A Djordjevic, R W Innes,
P L Kuempel & B G Rolfe 632

Transcripts of functionally rearranged gamma genes in primary T cells of adult immunocompetent mice

B Jones, S Mjolsness,
C Janeway Jr & A C Hayday 635

A unique T-cell receptor complex expressed on human fetal lymphocytes displaying natural-killer-like activity

P Moingeon, A Ythier, G Goubin,
F Faure, A Nowill, L Delmon,
M Rainaud, F Forestier,
F Daffos, C Bohuon
& T Hercend 638

A lymphoid-specific protein binding to the octamer motif of immunoglobulin genes

L M Staudt, H Singh, R Sen,
T Wirth, P A Sharp
& D Baltimore 640

A human DNA segment with properties of the gene that predisposes to retinoblastoma and osteosarcoma

S H Friend, R Bernards, S Rogelj,
R A Weinberg, J M Rapaport,
D M Albert & T P Dryja 643

Isolation of candidate cDNAs for portions of the Duchenne muscular dystrophy gene

A P Monaco, R L Neve,
C Colletti-Feener, C J Bertelson,
D M Kurnit & L M Kunkel 646

PRODUCT REVIEW

Archaeology gets graphic

B S Ottaway, L Sawyer & A Miller 651
Tokyo technology 652

MISCELLANY

100 yrs ago

580

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Professional appointments —
Research posts — Studentships —
Fellowships — Conferences —
Courses — Seminars — Symposia:

Back Pages

Next week in *Nature*:

- Benzene structure
- Multidrug resistance
- Sodium on Mercury
- Apolipoprotein B sequence
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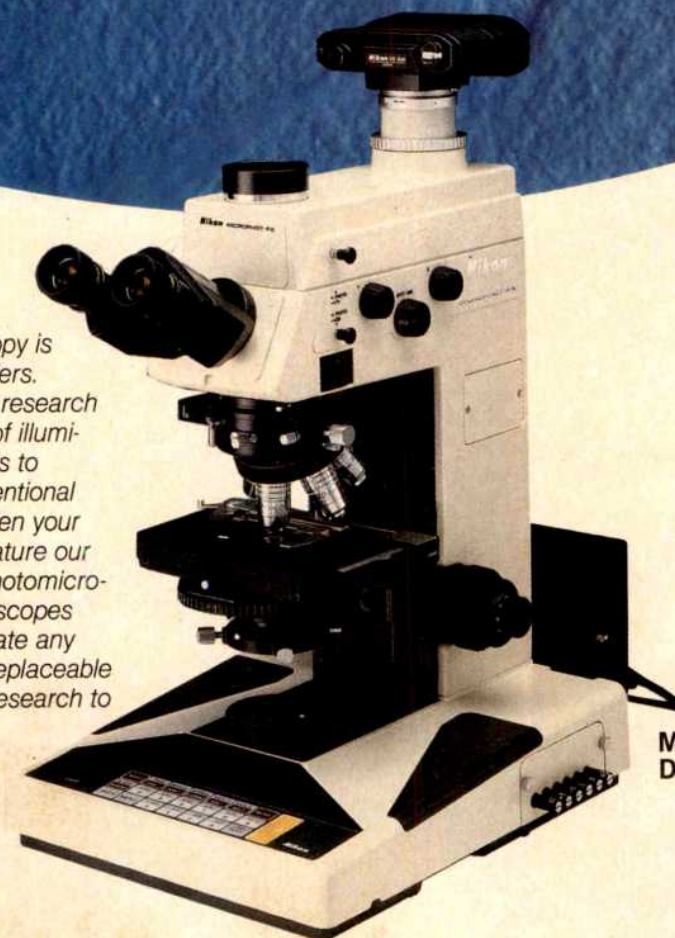
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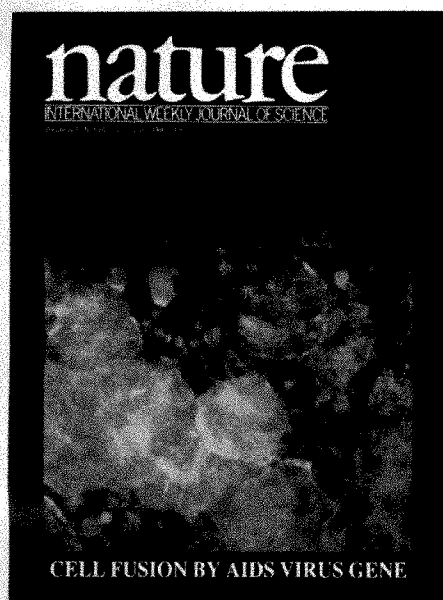
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OPINION

- British science over the hill 655
UNESCO'S new future? 656

NEWS

- US budget 657
Unapproved drugs for export 658
British science politics 658
Soviet Union
Mars spacecraft 659
US innovation 659
British research
Genome sequencing 660
Doubts about Department of Energy
Contraceptive vaccines 661
Soviet energy 662
European microchips 662
Nobel chemistry
Soviet Antarctic research 663
Nobel physics 663
European research

CORRESPONDENCE

- Paranormal/Systematics/etc. 664

NEWS AND VIEWS

- Turbulence assails fifth force 665
Theoretical chemistry: Back to the valence bond
Roy McWeeney 666

Nitrogen fixation: Finding a time and a place

A E Walsby 667

Melting and the surface

Robert W Cahn 668

Mantle geophysics: Variable viscosity makes waves

David A Yuen 669

Use of deuterated proteins in nuclear magnetic resonance

Paul Rösch 670

Nervous excitement over insect muscle patterns

Vernon French 671

Obituary: Fritz Lipmann

William P Jencks 672

Cosmology: Is omega equal to unity?

Joseph Silk 673

Mathematics: The Waring experience

Ian Stewart 674

SCIENTIFIC CORRESPONDENCE

Mystery solved

B J Ford ; A Ball 675

Turing's fly

D Gubb 675

Imanishi's impact in Japan

P J Asquith 675

The northerly extent of Chernobyl contamination

M Pourchet, J F Pinglot 676

& J C Gascard

BOOK REVIEWS

The Nazi Doctors: Medical Killing and the Psychology of Genocide

by R J Lifton 677

Benno Müller-Hill

A Hotbed of Genius: The Scottish Enlightenment, 1730-90

D Daiches, P Jones and J Jones, eds 678

J V Golinski

Hemoglobin: Molecular, Genetic and Clinical Aspects

by H F Bunn and B G Forget 679

D R Higgs

The Evolution of the Soul

by R Swinburne 679

D M MacKay

Transport and Diffusion Across Cell Membranes

by W D Stein 680

Clive Ellory

COMMENTARY

National performance in basic research

D C Smith, P M D Collins, 681

D M Hicks & S Wyatt

REVIEW ARTICLE

Stable and metastable metal surfaces in heterogeneous catalysis

M S Spencer 685

ARTICLES

A gene required for the specification of dorsal-ventral pattern in Drosophila appears to encode a serine protease

R DeLotto & P Spierer 688

Contents continued overleaf

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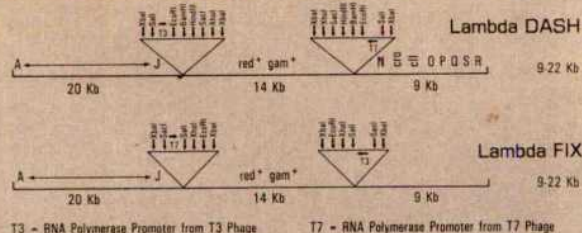
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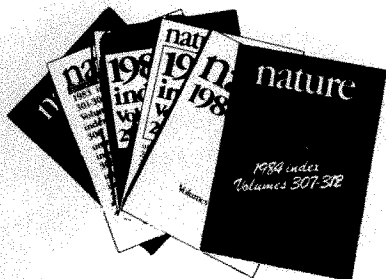
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Calbindin immunoreactivity alternates with cytochrome c-oxidase-rich zones in some layers of the primate visual cortex
M R Celio, L Schäfer,
J H Morrison,
A W Norman & F E Bloom 715

Single apamin-blocked Ca-activated K⁺ channels of small conductance in cultured rat skeletal muscle
A L Blatz & K L Magleby 718

Strategy by which nitrogen-fixing unicellular cyanobacteria grow photoautotrophically
A Mitsui, S Kumazawa,
A Takahashi, H Ikemoto,
S Cao & T Arai 720

An IgG autoantibody which inactivates C1-inhibitor
J Jackson, R B Sim,
A Whelan & C Feighery 722

Induction of CD4-dependent cell fusion by the HTLV-III/LAV envelope glycoprotein
J D Lifson, M B Feinberg,
G R Reyes, L Rabin,
B Banapour, S Chakrabarti,
B Moss, F Wong-Staal,
K S Steimer & E G Engleman 725

Isolation and expression of a complementary DNA that confers multidrug resistance
P Gros, Y B Neriah,
J M Croop & D E Housman 728

A 3' enhancer is required for temporal and tissue-specific transcriptional activation of the chicken adult β -globin gene
O-R Choi & J D Engel 731

Complete protein sequence and identification of structural domains of human apolipoprotein B
T J Knott, R J Pease, L M Powell,
S C Wallis, S C Rall Jr,
T L Innerarity, B Blackhart,
W H Taylor, Y Marcel, R Milne,
D Johnson, M Fuller, A J Lusis,
B J McCarthy, R W Mahley,
B Levy-Wilson & J Scott 734

Sequence, structure, receptor-binding domains and internal repeats of human apolipoprotein B-100
C-Y Yang, S-H Chen,
S H Gianturco, W A Bradley,
J T Sparrow, M Tanimura,
W-H Li, D A Sparrow, H DeLoof,
M Rosseneau, F-S Lee, Z-W Gu,
A M Gotto Jr & L Chan 738

MATTERS ARISING

Osteoclasts and haematopoietic stem cells in developing human bones
E Keleman
Reply: B A A Scheven & P J Nijweide 743

Interactions of N-CAM with heparin-like molecules
G Lubec
Reply: G J Cole,
A Loewy & L Glaser 743

Evolutionary relationships of human populations
A W F Edwards
Reply: J S Wainscoat, A V S Hill,
S L Thein & J B Clegg 744

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**Professional appointments —
Research posts — Studentships —
Fellowships — Conferences —
Courses — Seminars — Symposia:**
Back Pages

Next week in Nature:

- Energetics of Jupiter's moons
- Stratospheric ozone/nitrogen dioxide
- Novel liquid crystals
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- Giant panda phylogeny
- Brain tissue 8,000 years old
- Mapping the cortex
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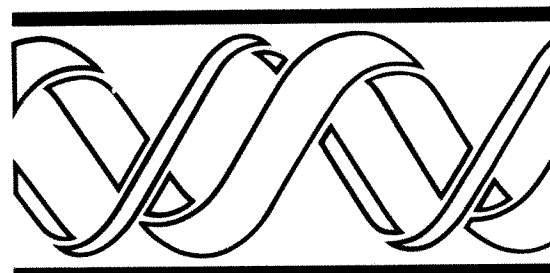
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Satellite Phase P4

Richard Calendar, UC, Berkeley

Soybean Seed Protein in Transformed Plants
Robert Goldberg, UCLA

The Immunoglobulin Gene Superfamily
Leroy Hood, CA Institute of Technology

Transcriptional Activation
Martin Rosenberg, Smith Kline & French Research Laboratories

Organ-specific Gene Expression in Chimeric Plants
Marc Van Montagu, Rijksuniversiteit Gent

Alpha Interferon
Charles Weissmann, Univ. of Zurich

DAY 2 • Receptor Biology: Towards New Pharmaceuticals

Receptor Regulation and Hypercholesterolemia
Michael Brown, Univ. of Texas

Antireceptor Antibodies
Mark Greene, Univ. of PA

Epidermal Growth Factor Receptor Gene
Ira Pastan, National Cancer Institute

The T-Cell Receptor
Susumu Tonegawa, MIT

Growth Factor Receptor Tyrosine Kinases
Axel Ullrich, Genentech, Inc.

The Interleukin-2 Receptor
Thomas Waldman, National Cancer Institute

DAY 3 • Redesigning Proteins

After the Cloning is Over
Charles Craik, UCSF

A Biophysical Approach to Protein Secretion
Lila Gierasch, Univ. of Delaware

Recovering and Refolding Active Oligomeric Proteins
Rainer Jaenicke, Universitat Regensburg

Genetic Identification of Protein Folding Pathways
Jonathan King, MIT

Modifying Enzymatic Activity and Stability
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OPINION

- Double-talk after Reykjavik** 745
The other big bang 746
Boycott of SDI

NEWS

- Strategic Defense Initiative** 747
Soviet Union
Missing — not dead
In vitro fertilization 748
US engineering 749
US biomedical research 749
Engineered organisms 750
European microelectronics 750
Refusniks 751
Biowaste 751
Italy to have research ministry at last 752
Bioregulation 752
Congress hears of high-tech trade deficit
Immunology in India 753
European space 753
European research

CORRESPONDENCE

- Divine intervention/**
Student loans 754

NEWS AND VIEWS

- New ways with classical mechanics** 755
Making of the nervous system 756
R W Guillery & C D Stern 756
Pauli principle in a gas 756
Peter McClintock

- Genetics of filamentous fungi** 757
John Fincham
Beauty is in the antennae of the beholder 758
Jonathan Bacon
Chemosynthetic tube worms 759
Gregory S Boland
Are there more than four fundamental forces? 760
Alvaro De Rújula
Detecting gravitational waves 761
David Blair
A new human herpesvirus 762
Robin Weiss & Carel Mulder
The demise of a living fossil? 762
Michael J Benton

SCIENTIFIC CORRESPONDENCE

- Even plants excrete** 763
B J Ford
Human ^{134}Cs / ^{137}Cs levels in Scotland after Chernobyl 763
W S Watson
Origin of HTLV-I virus in Japan 764
H Taguchi
Diatom mystery 764
T S McDonnell, F T Allgood, P O Baca & G E Miller

BOOK REVIEWS

- The Chimpanzees of Gombe: Patterns of Behavior** 765
by J Goodall
W C McGrew
The Particle Hunters 766
by Y Ne'eman and Y Kirsh
J H Mulvey
Collected Works of Kurt Gödel. Volume I, Publications 1929–1936 766
S Feferman et al., eds
David Miller
Biotechnology: An Industry Comes of Age 767
by S Olson
Tim Harris
Learning and Emotion: A Biological Synthesis. Volume 1, Evolutionary Processes 768
by Peter J Livesey
Eric A Salzen
Cosmological Constants: Papers in Modern Cosmology 768
J Bernstein and G Feinberg, eds
Michael Rowan-Robinson

COMMENTARY

- Uncertainty in science: is the giant panda a bear or a raccoon?** 769
E Mayr

ARTICLES

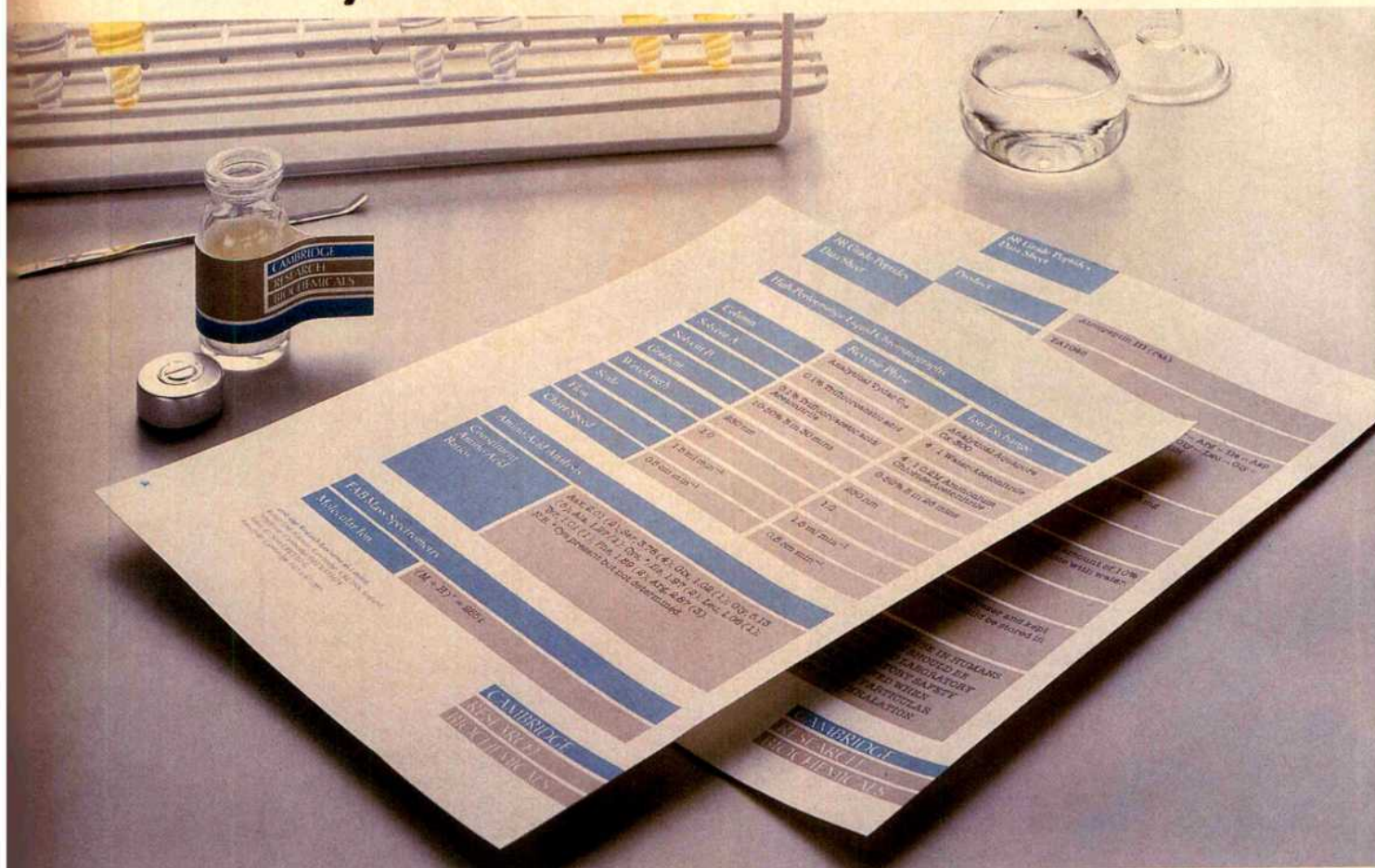
- Ozone and nitrogen dioxide changes in the stratosphere during 1979–84** 772
L B Callis & M Natarajan
Compensatory mutations suggest that base-pairing with a small nuclear RNA is required to form the 3' end of H3 messenger RNA 777
F Schaefe, G M Gilmartin, W Bannwarth & M L Birnstiel

LETTERS TO NATURE

- Is the Universe dominated by relativistic particles?** 781
R A Flores, G R Blumenthal, A Dekel & J R Primack
Is 1146+111B, C a lensed quasar or a quasar pair? 784
J P Huchra
Is the 1.5-ms pulsar a young neutron star? 786
J M Blondin & K Freese
Orbital acceleration and the energy budget in the galilean satellite system 789
R Greenberg, S R Goldstein Jr & K C Jacobs
Novel types of ionic thermotropic liquid crystals 791
D W Bruce, D A Dunmur, E Lalinde, P M Maitlis & P Styring
Sulphur-induced faceting of platinum catalyst particles 792
P J F Harris
Role of plutonium in low-pressure metamorphic belt formation 794
D R Lux, J J De Yoreo, C V Guldotti & E R Decker
Anoxic hypolimnion is a significant source of biogenic toluene 797
F Jütter & J J Henatsch
Kin selection and the problem of sperm utilization in social insects 798
K G Ross
Anatomical, cellular and molecular analysis of 8,000-yr-old human brain tissue from the Windover archaeological site 803
G H Doran, D N Dickel, W E Ballinger Jr, O F Agee, P J Laipis & W W Hauswirth

Contents continued overleaf

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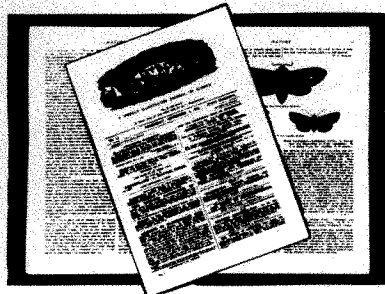
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Mapping human visual cortex with positron emission tomography

P T Fox, M A Mintun, M E Raichle,
F M Miezin, J M Allman
& D C Van Essen **806**

Calcitonin gene-related peptide regulates muscle acetylcholine receptor synthesis

H V New & A W Mudge **809**

cGMP-dependent protein kinase enhances Ca^{2+} current and potentiates the serotonin-induced Ca^{2+} current

increase in snail neurones
D Paupardin-Tritsch, C Hammond,
H M Gerschenfeld, A C Nairn
& P Greengard **812**

Polymerase activity in lymphocyte culture supernatants from patients with Kawasaki disease

J C Burns, R S Geha,
E E Schneeberger, J W Newburger,
F S Rosen, L S Glezen, A S Huang,
J Natale & D Y M Leung **814**

Antiviral effects of recombinant tumour necrosis factor *in vitro*

J Mestan, W Digel, S Mitnacht,
H Hillen, D Blohm, A Möller,
H Jacobsen & H Kirchner **816**

Tumour necrosis factors α and β inhibit virus replication and synergize with interferons

G H W Wong & D V Goeddel **819**

An activated Harvey *ras* oncogene produces benign tumours on mouse epidermal tissue

D R Roop, D R Lowy,
P E Tambourin, J Strickland,
J R Harper, M Balaschak,
E F Spangler & S H Yuspa **822**

Unusual priming mechanism of RNA-directed DNA synthesis in *copia* retrovirus-like particles of *Drosophila*

Y Kikuchi, Y Ando & T Shiba **824**

Phosphorylation of tubulin enhances its interaction with membranes

A J Hargreaves, F Wandosell
& J Avila **827**

PRODUCT REVIEW

Receptor modulation in brain slices

E W Karbon & S J Enna **829**

The news in neuroscience

830

NATURE CLASSIFIED

Professional appointments —

Research posts — Studentships —

Fellowships — Conferences —

Courses — Seminars — Symposia:

Back Pages

Next week in *Nature*:

- Io's kilometric radiation
- Icy-glue model for comets
- Carbonate in the mantle
- Giant subtidal stromatolites
- Opossum sex ratios
- Screening for carcinogens
- Introducing mutations
- Novel interleukin
- Bent DNA in yeast
- Plant genes turn on *Rhizobium* nodulation

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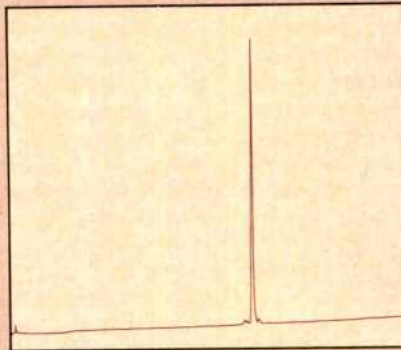
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*Ninhydrin values for amino acids coupled to proline are not quantitative.



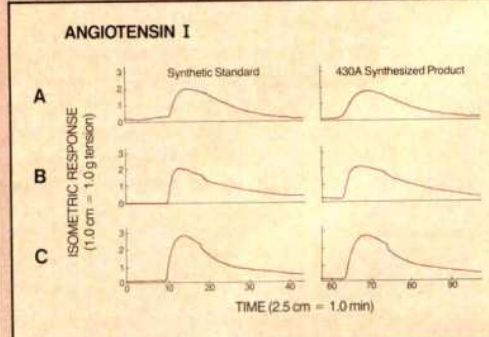
Angiotensin I, Crude

mobile phase 0.1% TFA/CH₃CN
gradient 0 to 60% in 60 minutes
flow rate 1.0 mL/min
detector 216 nm
column Brownlee, C-8, 300Å, 10µm
4.6 mm x 250 mm



Angiotensin I, HPLC Purified

mobile phase 0.1% TFA/CH₃CN
gradient 0 to ≥ 60% in 60 minutes
flow rate 1.0 mL/min
detector 216 nm
column Brownlee, C-8, 300Å, 10µm
4.6 mm x 250 mm



Panels A, B and C are isometric responses of two different Ile⁵-Angiotensin I—a synthetic standard and the 430A-produced, purified peptide—on three separate rabbit aortic strips. The responses produced by the Applied Biosystems Ile⁵-Angiotensin I were not significantly different than those of the standard. Sample concentrations were: in panel A, 564 ng/mL; in panels B and C, 500 ng/mL.

These response data were furnished by Drs. M. C. Khosla and A. Huse of the Cleveland Clinic Foundation.

Second chance for nuclear power?

Last week's conference on Chernobyl was a landmark in the development of nuclear technology, not least because of Soviet openness: was it a new beginning or the beginning of the end?

How do you turn a calamity into a celebration? The religious would advocate expiation or something of the sort. This is much what seems to have happened at Vienna last week, when a Soviet delegation unsure of the reception it would be given decided to offer an almost full account of the world's worst peaceful nuclear catastrophe. That this openness accords with what Mr Mikhail Gorbachev has been saying should not diminish the importance of what happened. Academician A.V. Legasov eloquently explained (see pp 3 and 25) that it is easier to be frank about triumphs than about disasters. But frankness paid handsome dividends. Chastened by Soviet candour, most listeners seem to have decided that more of the same would be jeopardized by hostile questioning. The result was a sense of camaraderie not witnessed in this field since the first heady days of the peaceful exploitation of atomic energy more than thirty years ago. Two things must be said about that development: first, nothing but good can come from closer collaboration on Chernobyl and on nuclear safety in general and from a stronger role for the International Atomic Energy Agency and, second, that the camaraderie by itself will not chase off the political problems of nuclear power.

The difficulty is that what went wrong at Chernobyl on 26 April could have happened anywhere. That is the plain truth, which no amount of technical comparison of different reactor types can possibly conceal. Moreover, there have been several occasions in the recent past when nuclear accidents, luckily smaller in scale, have been brought about because operators have chosen to disregard the regulations they are supposed to live by, or have been deserted by common sense and elementary caution. Who can forget the fire at the Brown's Ferry reactor of the Tennessee Valley Authority caused by a maintenance man's decision to use a naked candle flame in a confined space? The accident at Three Mile Island would probably not have happened if the reactor operators had followed the rules and not their hunches. The Canyon Diablo reactor in California, originally built with some of its components installed back to front, and then expensively modified, could have become an equally expensive monument to human folly if the errors had not been spotted.

Errors

The chain of events leading to the accident at Chernobyl stands out because of the sequence of errors the operators chose to make, all of which are consistent with what may have been the belief that a reactor operating at low power is inherently less dangerous than one operating at high power. Only some such conviction, coupled with the blend of complacency and arrogance that springs from a reputation for success, can explain why experienced people met the prospect that safety systems might frustrate a planned experiment by switching off those systems. Thus might a person with angina attempt to hide the pain in his chest by swallowing aspirin.

This is why no great purpose can be served by detailed comparison of the Soviet reactor with other machines elsewhere. It is nevertheless the case that the Soviet reactor embodied a recipe for positive feedback between reduced cooling efficiency and

increased heat production. So, as the cooling water turned to steam in the last few seconds before the reactor ran amok, the power production went on rising even faster. Reactor managers elsewhere may rightly claim that their machines do not have this particular fault, and that even a contrived approach to catastrophe would be more moderate. There is also much that may (and should) be done by means of electronic locks and keys to guard against contrived accidents such as that at Chernobyl. Intelligent (not bureaucratic) procedures are also valuable, as are the techniques worked out to help long-distance aircraft pilots, and others doing demanding but boring jobs, to remain alert. But nuclear safety engineers elsewhere cannot (and, to their credit do not) absolutely claim that "it couldn't have happened here in [fill in the blank]".

Procedures

How, with such a fuzzy task ahead of them, can the world's nuclear engineers hope to persuade their governments to continue building nuclear power stations? Their main argument is what it has always been, that for many countries there is no economic choice. But the frankness of the Soviet Union last week about the course and the physical consequences of the accident at Chernobyl also demonstrates that there are many countries that could not survive an accident on such a scale, economically and socially. So it is inevitable that governments will now take a keen interest not just in the way nuclear power stations are designed and built but also in the way they are run. The US Nuclear Regulatory Agency, which has a fearsome reputation among reactor operators for bumbling interference, is forever fining people on the grounds that they have broken agreed rules. Now, no doubt, similar systems of invigilation will be copied elsewhere. Nuclear engineers should not protest too loudly; in the long run, some such procedure may be a necessary, if transitional, means of restoring public confidence.

But even tougher regulatory regimes for nuclear energy will not always satisfy the public anxiety engendered by Chernobyl. Some governments will no doubt decide to follow Sweden (which, with one of the best safety records in the world, has decided to build no more nuclear power stations) or even Austria (which has decided to dismantle its own plant, which has not been switched on). There is no reason why particular governments should not take such apparently iconoclastic decisions, which can always be reversed when circumstances change. But in the major industrial economies without indigenous cheap fuel, the two big creditors on the international trade markets (Japan and West Germany) in particular, the economic case for perseverance cannot be dismissed. But after Chernobyl, even there a tighter regulatory regime will be an advantage.

The obvious snag in the regulatory approach to safety is that, in the presently polarized state of opinion on nuclear power in many Western countries, there is a kind of Gresham's law that drives safety standards downwards. Soviet spokesmen in Vienna last week were right to complain at the decisions of European governments to ban food imports from the East whose radioactive content was an order of magnitude more than necessary. The British government, which banned the sale of new lambs

because the caesium content of some of them exceeded another arbitrarily low limit, may like to know that the government of Argentina fixed an even lower limit to safeguard its people (and the customers for its meat exports) from Chernobyl fallout, secure in the knowledge that tropospheric air masses do not cross the Equator. This is why one of the most important tasks with which the international agency has been saddled is that of negotiating standards of radiological safety which are recognized internationally to be sensible. That will not be easy.

Regulation

Regulation is also a means by which anxiety about nuclear safety may be excited. Each enforcement of a regulation may be represented as a sign that catastrophe has been only narrowly averted. In Britain, for example, where the nuclear issue is well on the way to being as contentious as in the United States, with the recent practice of making public announcements of all radioactive discharges to the environment, each few becquerels that find their way into the atmosphere or some water-body are greeted as a sign of the ending of the world by those committed to the view that nuclear energy is by definition an abomination. But the temptation to abandon openness must be resisted. The best, indeed the only hope, is that people will learn from repetition that radioactivity does not differ from other environmental pollutants in being dependent for the damage they do on their amount. Chernobyl was a serious disaster (and could, with bad luck, have been a lot worse.) Most radiation scares are quite different, but may malevolently be used to stir up trouble.

That is only one reason why it must be hoped that the regulatory approach to nuclear safety will in due course be overtaken by a more positive solution of the problem. In at least one respect, the Soviet system appears to have contributed substantially to the successful handling of the emergency: the educational system makes Soviet citizens knowledgeable about a variety of technical matters, and better able to appreciate the stochastic character of radiation injuries than is likely to be common elsewhere. It is also true, of course, that the Soviet system requires an unnatural degree of compliance with centrally laid plans, such as the decision that young children should be evacuated separately from their parents from the 30-km zone around the reactor. The moral for other would-be civil nuclear powers is that there is much to be gained from a deeper general understanding not merely of the putative benefits of nuclear power, but also of the risks. Even more openness will be needed.

None of this will ensure that operators behave responsibly. One of the ingredients missing from last week's Soviet report, for obvious reasons, is a full account of the reasons why the plant operators thought it necessary to depart so far from normal practice at the damaged reactor. For that matter, what is known of the frequency of corner-cutting without mishap there and at other power stations? And what of the degree to which the Soviet system, now more than ever one in which liberal people tolerate only grudgingly state institutions that have lost general respect, may have contributed to the accident by engendering cynicism about even sensible rules and regulations?

The counterpart in the West is the willingness of contractors to skimp on the quality of equipment supplied or of managers to discard warnings from professional people in the pursuit of what would be called "norms" in the Soviet Union. The loss of the US space shuttle last January refers. The only remedy that will in the long run work is that professional engineers, whatever their status in a hierarchy, should have the right to speak their minds and to be listened to. If it is accepted that the general public should be well-informed, should not the professional people who carry the responsibility enjoy a degree of independence they are now denied? That, of course, will be a hard reform to implement, not merely in the Soviet Union. The Soviet account of Chernobyl is that of a thoughtless crew eager to finish off a tedious chore. Would they have behaved like that if they were in charge, not merely shift-workers? □

Chips in big boxes

The personal computer manufacturers are in calm waters, and may become sleepier.

CURIOUS things are going on at the bottom of the computer market, the battlefield on which dozens of companies have lost their shirts (or, more cannily, other people's) in the past three years. Surprisingly, prospects are looking up for the companies that have managed to survive, while even business (the prospects for the next quarter) is improving. What can have changed? And why are many manufacturers of electronic components, especially in the United States, still wailing loudly at what they assert must be unfair competition from elsewhere?

What has been happening is an illustration of a familiar and easily recognized economic phenomenon. There was a time, roughly a decade ago, when toy manufacturers were seeing what uses they could make of the semiconductor chips that much more august manufacturers were used to building into mainframe computers. Perversely, some toy-makers built the chips into toy computers, which the younger generation occasionally lent to its elders. Not much time was needed for entrepreneurial elders to sense a market for machines selling for hundreds, not thousands, of dollars, which is how the trade in personal computers sprang to life. But as with the British railway construction boom of the mid-nineteenth century, eager investors were much more numerous than those among them who could grab a substantial share of the market. On the railways, the outcome was predictable. Companies swallowed each other and became bigger in the process until there was nowhere else for them to go, whereupon the incentive for technical change melted away. The result is modern British Rail.

Computer users are more fortunate, so far at least. The shake-out has been traumatic for many companies. Outright bankruptcy has been more common than merger and amalgamation. But consolidation and ossification have not followed. Part of the benefit, for users if not for established manufacturers, is that there seems to be an endless supply of upstart companies willing to compete with the established fellows on price, but that are unable consistently to beat them on performance. Both kinds of companies have also benefited, the upstarts from the money they have sometimes made, the established fellows from the demonstration provided at little cost by the others that there is a huge and sustainable market to work. The competition has become so volatile that the big fellows fear they will be swallowed by the upstarts; some are even thinking they should compete on technology.

That is why the big fellows are at last waking up. IBM's personal computer (called PC) is now long in the tooth, but there is a better version on the way. It may be more significant that Digital Electronics has thought it worthwhile to sell a cheap (or cheapish) computer that is compatible with its own minicomputer called VAX. Even in Europe, once nearly disappeared companies (such as the British Acorn) are talking as if they have a future again (under the Olivetti umbrella).

So is the shakeout at an end? Unfortunately, at least for manufacturers, no. The plain truth is that the machines now on the market are still rudimentary devices, whose big boxes are still mostly filled with old-fashioned wiring. People talk of the time when it will be possible to carry the power of a mainframe computer in a shopping bag, but the lap-top computer has only just become practicable and affordable.

It will be interesting to see whether the new chip of which Intel is now boasting will be that much more capable than Motorola's new product at enabling the design of decisively superior machines, but past performance does not suggest that even the thrusting entrepreneurs in the business are that adventurous. Their products are still most of all conspicuous for the size of the boxes they inhabit. There is a long way to go before their promise is delivered. □

Chernobyl

Soviet frankness creates sense of solidarity

Vienna

THE chief and perhaps only beneficiary of the Chernobyl accident may be the International Atomic Energy Agency (IAEA), which organized last week's technical meeting on the subject. The meeting finished with no fewer than thirteen suggestions for extra work on reactor safety the agency should pursue.

But although the agency in the past few months has been able to increase its nuclear safety budget by \$2 million a year, or roughly a third, by reallocation of present resources, IAEA will have to wait for a governors' meeting a month from now to learn whether member governments will back last week's recommendations with extra funds. The obvious danger is that governments may not be as strongly committed to nuclear power as the reactor people and other specialists last week.

Meanwhile, it is generally accepted that the technical meeting was a huge success, chiefly because of the frankness of the Soviet report on the reactor accident. (For a more detailed report, see p. 25.) Thus the long catalogue of incomprehensible errors leading to the accident, which is a sufficient explanation of it, has not restrained the Soviets from listing the technical defects of their reactor design.

The meeting nevertheless began nervously. The leader of the Soviet delegation, Academician V. A. Legasov, deputy director of the Kurchatov Institute in Moscow, explained that at the outset he and his colleagues were uneasy "that we were sharing not our successful experi-

ence with nuclear ice-breakers or an encounter with Halley's comet, but a painful experience, which was a great tragedy for us and which has worried many people elsewhere in the world".

Legasov had introduced the Soviet report by asking for constructive suggestions and criticism, and finished by offering continuing cooperation on nuclear safety and related issues. Almost all other delegates set out consciously to create what Legasov called "a sense of solidarity". Delegates have argued that the Soviet delegation would have been less than forthcoming if subjected to outspoken criticism.

One result of that strategy may nevertheless be that some questions in which IAEA member governments are interested, such as the apparent delay in the provision of accurate information from the Soviet Union, were not fully explored.

Even so, more than 700 questions were submitted by fewer than half as many delegates. The Soviets will answer in writing those not dealt with last week.

Delegates, including those from the Soviet Union, have been most of all puzzled by the apparently capricious behaviour of the operators of the reactor on 25 and 26 April, for which there seems no convincing explanation. But some of the control-room errors, and especially the failure, early on the morning of 26 April, to reset the working power level for the automatic control-rod system, appeared familiar to some Western plant managers.

Measurements of the radioactivity released from the reactor have confirmed that the accident is the worst so far. Fallout in the Soviet Union is estimated at 50 megacuries, with as much activity again in gaseous form. Doses to some people within the 30-km evacuation zone are estimated to have ranged up to about 70 rem, and plans are being laid for a workshop at which the details of a follow-up study extending over decades can be discussed. But the meeting took the view that the Soviets had overestimated the total collective radiation dose to the population of Western Russia, perhaps by a factor of 10.

One striking feature of the Soviet report is its coolness towards bone marrow transplantation in the treatment of those exposed to large doses of radiation, some as large as 1,600 rem. The report says that extensive burns, many by beta-irradiation of the skin, excluded transplantation for the most seriously affected patients, while those in whom it was used included some in whom spontaneous recovery of marrow

function caused host-graft reactions. These, the report says, may have contributed to the deaths of two people.

Although fallout external to the Soviet Union has been postponed to future discussion, the responses of some Western governments were roundly criticized by Professor L. A. Ilyin, vice-president of the Soviet Academy of Medical Sciences and director of the Moscow Institute of Biophysics. He saw no need for the distribution of iodine tablets in Poland nor for restrictions on food imports from the East by West European governments.

John Maddox

Cuts hurt basic science in France

THE final figures for the 1987 French budget show that the minister in charge of research, physicist Alain Devaquet, has had some success in protecting scientific research from the ravages of a monetarist government. But François Gros, ex-director of the Institut Pasteur and science adviser to successive prime ministers in the previous socialist government, last week criticized current policies.

Gros has just returned from visits to Japan and the Soviet Union, which he sees as rising competitors for French biologists. He says that an apparent increase of 10 per cent in the budget of the Centre National de la Recherche Scientifique (CNRS) shows "a degree of protection for basic science" but should be seen against an 8 per cent cut imposed in May. The budget will now be 2 per cent less than it was to have been in 1986.

Up to 500 posts for technicians and a planned 2 per cent increase in research staff are also likely to be cut. Under the previous government, France had been increasing its competitiveness in science in relation to other countries, but that trend would probably now reverse, said Gros. "Increase in competitiveness comes from increase over inflation." The need for advanced equipment and technicians is growing rapidly in biology and real increases are necessary to stay ahead.

Although the basic research budget is to be held at 1985 levels, ministry figures confirm cuts in support for applied research. According to Gros, those receiving funding under the previous government's "mobilisation programme" for biotechnology, for example, have suffered setbacks of nearly 50 per cent.

The ministry of research, however, says the planned spending levels of the previous government were "unrealistic", and the applied programmes ill-planned and wasteful. Relevant programme agencies should be forced to be more practical by earning their own way, raising contracts with industry and selling services, the government argues.

Robert Walgate

Plan for action

The several technical sessions of last week's meeting selected the following topics for research, study and consultation under the aegis of IAEA.

- Further study, experimental as well as theoretical, of the accident.
- Design of the man/reactor interface.
- Training (and perhaps accreditation) of operators.
- Promulgation of agreed safety standards.
- Firefighting at nuclear plants.
- Chernobyl fallout.
- Decontamination techniques.
- Exchange of uniform monitoring data.
- Estimation of biological effects (especially for the 135,000 evacuees).
- Long-delayed effects.
- Acute radiation injuries.
- KI side-effects.
- Dosimeter inadequacy.

West German research

Industry's subsidy attacked

Hamburg

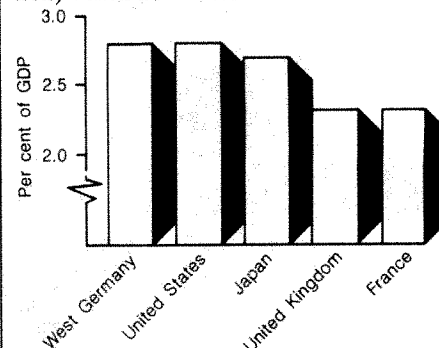
WITH a healthy balance of payments, a strong currency and low inflation, West Germany's economy is the strongest in Europe — and much of that strength is based upon successes in high-technology industries. Despite all this, there is concern that West Germany might not be keeping up with other countries in technology and scientific knowledge. And there is controversy over just what to do about it.

Decisions made by BMFT, the Federal Ministry of Research and Technology, hold the key to many of the major research and development projects, especially those requiring long-term investment. The minister at the head of BMFT, Heinz Riesenhuber, has his own ideas on how best to compete with the United States and Japan in fields such as biotechnology, space and information technology — he watches the markets to try to identify potentially profitable areas at an early stage and then sets up subsidy programmes to help industry to develop competitive research independent of government.

This "private enterprise" approach is

very much in line with the policies of Riesenhuber's party — he is a Social Democrat — and it seems to be paying political dividends, as he is regarded as a leading light in Chancellor Kohl's cabinet. The scientific value of BMFT's decisions is disputed by some experts, however. The nuclear power programme is one that has been criticized: more than DM3,000 million has been sunk into work on the fast-breeder reactor over the past decade or so, while high-temperature reactor technology has been neglected (only one prototype reactor has been built, in Hamm) and support for alternative energies such as solar power has been paltry. But Riesenhuber's ability to change priorities for BMFT's spending is severely limited: of a total civil budget of DM18,600 million, BMFT is responsible for DM7,500 million, but nearly three-quarters of that is tied up in long-term projects, support for major institutions and West Germany's contributions to international projects such as CERN and the European Space Agency. What should be done with the remaining funds — DM2,502 million last year — is hotly disputed.

In 1985 the nuclear programme took a large share of BMFT's industrial subsidy — DM740 million — leaving DM1,780 million with which to influence research trends in the rest of industry. Riesenhuber has favoured smaller companies (with an annual turnover of less than DM500 million) which now receive DM710 million a



West Germany's total research spending is 2.8 per cent of gross domestic product, which compares favourably to that in Japan and the United States. Two-thirds of this is met by trade and industry and one third by government.

year, whereas the larger companies now get around DM856 million compared with DM1,204 million in 1981.

This government support has to be matched with an equal investment from the company receiving the subsidy, but this has not prevented the accusation that government money is being spent extravagantly to support research that the companies would otherwise have to pay for themselves to survive in a free enterprise economy.

In particular, the Christian Democrats' coalition partners, the Free Democrats, are strongly opposed to the plan to subsidize Siemens and Philips to the tune of DM320 million over the next few years for the development of the four-megabit chip.

Riesenhuber, however, remains convinced that BMFT is following the right path. Support of DM1,000 million to 1989 in biotechnology is intended to achieve "jumps of perception" (see *Nature* 316, 287; 1985) and the number of scientists carrying out basic research in information technology should rise to 4,000 in 1992 from today's 1,700. And despite the problems of struggling with the very high cost of space research, Riesenhuber hopes to be able to support the Hermes shuttle project as well as participating in the US space station and the Ariane-5 launcher.

On nuclear power and alternative energy research, events and political expedience are causing some rethinking of BMFT policy. In the aftermath of Chernobyl, the views of environmental groups and the Federation of Solar Energy, an association of institutions and companies working on wind and solar energy, appear more attractive and Riesenhuber has announced that his ministry will support every promising project dealing with wind and solar energy.

Jürgen Neffe

French science

Researchers all at loggerheads

MEMBERS of the principal French researchers' trades union, the Syndicat National des Chercheurs Scientifiques (SNCS), earlier this month halted government plans to increase the power of universities over the Centre National de la Recherche Scientifique (CNRS), which funds the cream of French science, by walking out of a key decision-making meeting.

This action, according to SNCS officials, forced the new management at CNRS to negotiate with them over the issue, which it had refused to do earlier. The conflict centres on the reconstitution of the Comité Nationale, the recently dissolved collection of 44 elected specialist panels that makes the final decisions on appointments, promotions and grants at CNRS. The previous Comité was disbanded after it was declared illegal, leaving newly appointed scientists unsure whether they have posts at CNRS or not.

The proposition that university teachers and professors should have increased representation at the expense of CNRS scientists has provoked bitter opposition from SNCS, containing as it does a large proportion of CNRS scientists.

According to an SNCS official, the CNRS management is independently opposing the changes, and conflicting proposals from both management and SNCS are now going forward for the

ministry of research and higher education to disentangle. The union objects to two major proposals. The first is that Comité members would be from a single list, mixing both full-time CNRS scientists and university staff. In some disciplines, CNRS staff are completely outnumbered by those from university, so this would represent a total loss of power of CNRS researchers. The second proposal is that the number of middle-ranking researchers and technicians in each Comité panel would be reduced. The net result, the union would say, is that power over the CNRS would be too concentrated in the hands of the "mandarins".

The real issue is the long-standing competition between CNRS and the universities. Some university professors and departments, particularly in the humanities, social sciences, law and medicine, remain extremely reluctant to accept the power of CNRS, which has remained partly separate from the university system, despite the existence of many joint laboratories. Some objectors still go so far as to demand the dissolution of CNRS and its medical counterpart, INSERM, and a private bill (not sponsored by the government) to exactly that effect is to be read in the French National Assembly next session. The bill is unlikely to become law, but is certain to sustain conflict.

Robert Walgate

Ecological warning

Threat of floods from saline lake

THE resort town of Muysaly in the Soviet Union's Kazakh republic is in imminent danger of being "wiped off the face of the Earth", according to an inspector from the Soviet water resources ministry. The threat of a major ecological disaster comes from the saline Balkuduk lake, which has received no less than 80 million cubic metres of waste water from the industrial area around the town of Pavlodar.

Speaking on Moscow radio, the ministry inspector Vladimir Denisov warned that the lake is now so overburdened with water that a heavy storm might be enough to release flood waters that would not only engulf Muysaly, but also cause severe problems of pollution, with the polluted water being drained in to the river Irtysh, the primary water source for Kazakhstan and West Siberia. The pollution would cause millions of roubles of damage which would take several years to repair.

The management of a tractor plant, the biggest user of the Irtysh water (10,000 m³ daily), pays no attention to the conservation problems said Denisov; nor does the Ministry of the Chemical Industry, which has a major responsibility for industry in the area. The officials who should be most concerned with pollution, Denisov said, put their efforts instead into telephoning Moscow to obtain a stay of implementation of anti-pollution measures. Directives on building dykes and installing anti-pollution equipment are being ignored.

Water supplies to Kazakhstan, and the whole of Soviet Central Asia, have recently become a sensitive political issue. Russian writers of the "Villager" school have condemned plans to divert the north-flowing rivers to irrigate the arid steppes on the grounds that it would entail the destruction of treasures of Russian archaeology. The peoples of Central Asia, on the other hand, see such criticisms as a Russian move to establish superiority over the other ethnic groups of the Soviet Union. The recent Politburo announcement that it has been deemed "expedient" to end work on the diversion scheme "in connection with the need for further study of the ecological and economic aspects of the problem" will undoubtedly increase this resentment.

Denisov's revelations, therefore, however firmly based, are likely to be treated with suspicion by the inhabitants of Kazakhstan. His attacks on the Pavlodar local authorities will almost certainly be interpreted by the locals as a ploy to suggest that, as the Kazakhs cannot manage their own water, they have no right to extra supplies from the heartland of Russia.

Vera Rich

Biological weapons

New view from the Pentagon

Washington

THE new possibilities offered by recombinant DNA technology seem to have led the United States to change its view of the threat posed by biological weapons. US representatives at the second review conference of the 1972 Biological Weapons Convention, which starts this week in Geneva, will argue that it is now possible to produce effective biological weapons quickly and clandestinely. The key problem of preventing them from affecting friendly forces seems to be surmountable.

Because the United States believes the convention cannot be made verifiable, it is likely to resist diplomatic initiatives to strengthen it. US officials stress that the United States has no intention of abrogating the convention, and that it opposes the production of biological weapons.

But it is likely to resist expected proposals to clarify key definitions, such as the

partment. Douglas J. Feith, deputy assistant secretary of defence for negotiations policy, wrote that "new technology has exploded the standard ideas about biological weapons that prevailed ten or more years ago".

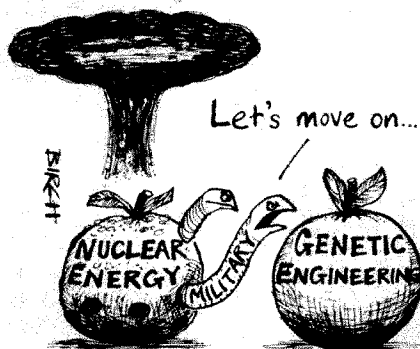
Feith says that although biological weapons had previously been considered of questionable value because of difficulties of control and storage, it is "now possible to synthesize biological weapons agents tailored to military specifications" by, for example, "circumventing immunogens or antigens that the other side is suspected to possess". Together with advances in scale-up technology, this means that "the prevailing judgement of years ago that biological weapons are not militarily sustainable is quite unsustainable". While some independent experts are sceptical about quite how easy it would be to produce an effective engineered weapon, the Pentagon is not in a mood to make changes.

Feith says that biological weapons favour offence over defence, because it is easy to produce new agents but difficult to develop antidotes. He also claims that the Soviet Union has built a "large organization to develop and produce offensive biological weapons", and repeated the US claim that the Soviet Union has used mycotoxin weapons banned by the convention in South-East Asia.

Although recent data question this claim (see *Nature* 321, 554; 1986), Feith says the fact that "mycotoxins occur in nature in certain colder areas ... has made it easy for states to refuse to come to the unpleasant conclusion that biological weapons have been used and that something should be done about it". Because of the controversy about "yellow rain", the Soviet Union "can hardly have failed to observe that the costs of biological weapons use have proven manageable, indeed virtually nonexistent".

US research into biological weapons has been hampered by a permanent injunction granted two years ago to Jeremy Rifkin's campaigning organization, the Foundation on Economic Trends, which prevents the Army from going ahead with its plans to build a \$300 million biological aerosol test facility at Dugway Proving Ground in Utah until an environmental impact statement has been prepared. Rifkin has filed suit again this week, this time seeking to halt the Army's entire biological weapons research programme pending environment impact statements. Rifkin has also established a \$100,000 whistle-blower's defence fund for microbiologists harassed or losing employment for publicizing illegal biological weapons research.

Tim Beardsley



distinction between offensive and defensive research, on the grounds that to do so would probably lead to a two-tier regime. Officials say the United States will also raise again its charges that the Soviet Union has repeatedly violated the terms of the convention by using toxin weapons in Afghanistan and South-East Asia.

The convention was drafted in 1972 and has since been signed by 102 countries. It forbids signatories from producing, stockpiling or using offensive biological weapons, but allows defensive biological weapons research. Critics contend that much ostensibly defensive research — for example, into vaccines against biological weapons — could also help in the manufacture of more fearsome offensive weapons. The Pentagon estimates that the size of the defensive biological weapons programme will increase from \$31 million in 1984 to \$63 million in 1987.

The administration's changed view of the feasibility of developing biological weapons was spelled out recently in testimony by the Department of Defense to the House of Representatives' intelligence committee. The testimony is unusual in that it was not requested by the committee, but volunteered by the de-

Energy research

Tapping the tropical seas

Tokyo

JAPAN'S industry and electric power companies are set to develop a vast pool of untapped energy — the tropical Pacific Ocean. This month they will help to launch a non-profit fund for the development of ocean thermal energy conversion (OTEC), aimed at helping the islands of the South Pacific.

OTEC is simple in principle. All you need is ready access to warm water from the ocean surface and cold water from its depths, resources that Pacific islands have in limitless amounts. In a closed system, warm ocean surface water (about 25°C) is pumped into heat exchangers to vaporize ammonia or freon which expands to drive a turbine. At the same time, cold water (about 4°C) from the deeper ocean (600–1,000 m) is pumped up to condense the vapour in separate heat exchangers, allowing the cycle to start again.

One of Japan's leading researchers in the field is Professor Haruo Uehara of Saga University in Kyushu, who in collaboration with industry has established two experimental plants; a 50–60 kW plant in Tokunashima island south of Kyushu, built by the Kyushu Electric Power Company, which operated from 1983 to 1985; and a 75 kW plant at Imari City near Saga University, built at a cost of ¥300 million (£1.3 million) with funds from the Ministry of Education, Science and Culture.

Uehara's next step is to design a commercial plant of 3–10 MW in collaboration with Nippon Kokan, a giant steel producer that is branching out into new fields. But even such small commercial plants will cost thousands of millions of yen to build and will be beyond the reach of their best potential customers, the islands of the South Pacific. This is where the soon-to-

be-established fund comes in.

More than 100 Japanese companies including the Tokyo and Kyushu Electric Power companies, Nippon Kokan and Mitsubishi Heavy Industries are expected to participate as supporting members of the fund which, with an initial operating budget of ¥500 million (£2 million), will provide grants to developing nations wishing to set up OTEC plants. The main backer, however, is expected to be the Japanese government.

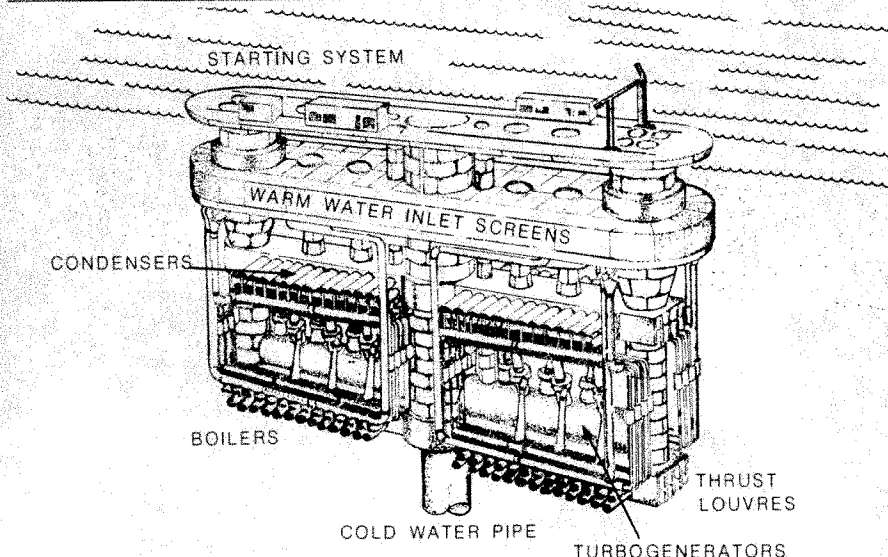
One of the most likely first customers for an OTEC plant is the Republic of Nauru, a tiny Pacific island on the equator, which already has experience of operating a 100-kW experimental plant.

Several different designs are envisaged, including offshore floating plants, underwater shelf-based plants, and plants based on land. And they could include a marine hotel, aquarium and desalination plant.

But will the vast amounts of cold water pumped out of OTEC plants upset the marine ecosystem of the islands? Even a 10-MW plant requires a flow rate of about 100,000 tonnes per hour. Not so, say advocates of OTEC. In fact, they claim the cold nutrient-rich water is positively beneficial and can be used for the cultivation of abalone and fish.

The cost of OTEC-produced electricity for a 3-MW plant is a hefty ¥50/kWh, because of the high capital cost of the plant but for a 100-MW plant this figure drops to ¥19, according to Uehara, and OTEC would then be capable of competing with other sources of electricity in Japan. The most likely first candidates for OTEC power in Japan are the Okinawa and Izu islands, both of which are bathed by the warm waters of the Kuroshio current and lie close to cold deep water.

David Swinbanks



Archaeology

Conflict goes on over Congress

Southampton

WITH the start last Monday of the troubled World Archaeological Congress here, the organizers began to count the cost of their ban on scientists from South Africa and Namibia and the subsequent removal of recognition of the meeting by the International Union of Prehistoric and Protohistoric Sciences (IUPPS — see *Nature* 319, 251; 1986). Clearly the end of the congress will not be the end of the story.

In spite of the problems, about 1,200 people turned up to register, which was fewer than the best hope of 2,000, but the loss of about 420 people who withdrew after the ban was enforced has hit particularly hard because these were mostly well-funded scientists from the United States and Western Europe. The total budget of the congress, estimated at about £0.5 million, has suffered further from the withdrawal or reduction of sponsorship, particularly from the United States. In consequence, administrative support has been cut back, and the number of travel grants for participants from developing countries has been reduced.

The congress has been particularly vulnerable to financial issues because of the novel features the organizers claim for it. The emphasis has turned away from Europe and North America and centres on particular themes to which archaeologists from developing countries can contribute more easily. The organizers have also invited several people recognized by their communities as being experts on their own cultural heritage. The bias towards participants from developing countries has required a greater reliance than usual on external support.

This shift in emphasis, however, is seen as extremely important by the organizers, headed by Professor Michael Day (St Thomas's Hospital Medical School, London), and has heightened the conflict between them and IUPPS, which is seen by many to look mostly towards European issues. This conflict will be the key issue at a plenary session to be held on Saturday 6 September, and it is hoped that the differences that have arisen over the ban on South African and Namibian scientists can be resolved before the official IUPPS World Congress scheduled for Mainz in 1987 takes place. If they cannot agree, Day believes that further "unofficial" congresses may result. But it is the hope of Richard Leakey of the National Museums of Kenya that "those who opposed the Southampton meeting will accept that they were wrong and a stronger world forum for archaeology will be the result".

Nigel Williams

Blood products

Hepatitis screening extended

Washington

SPURRED by growing concern that non-A and non-B hepatitis may represent a more serious health hazard than previously thought, the American Association of Blood Banks (AABB) announced last week that its members will begin screening all donated blood for evidence of non-A, non-B hepatitis. But as AABB officials are quick to acknowledge, such screening leaves much to be desired, as no direct tests for non-A, non-B hepatitis exist.

Blood banks hope to get an indirect indication of the potential for a donor to transmit non-A, non-B hepatitis by using two different blood tests. One measures the level of alanine amino transferase (ALT), commonly used as an indicator of liver dysfunction. The other tests for the presence of antibodies to hepatitis-B core antigen (anti-HBc). High levels of donor ALT and the presence of anti-HBc both correlate with subsequent development of non-A, non-B hepatitis.

The debate over whether to use one or both of these tests to screen donated blood has been raging for years. The ubiquity of non-A, non-B hepatitis as the cause of post-transfusion hepatitis became clear only after the development of a test for hepatitis-B surface antigen in the early 1970s. Between 7 and 17 per cent of all transfusion recipients develop post-transfusion hepatitis. Now, with effective screening for hepatitis-B, non-A, non-B hepatitis is estimated to account for more than 90 per cent of these cases. Even before such screening, Stephen Feinstone of the laboratory of infectious diseases at the National Institutes of Health (NIH) estimates that two-thirds of post-transfusion hepatitis cases were non-A, non-B.

The American Red Cross is also implementing ALT testing at its blood banks; the programme began on 7 July, and is expected to be completed by 1 October. AABB expects to implement testing in its member centres by 30 November. A third organization for blood banks, the Council for Community Blood Centers (CCBC) accounting for approximately one quarter of all blood collections, has not officially declared a position on ALT testing. But its president, Richard Counts of the Puget Sound Blood Center, says most members will go ahead with ALT screening.

Far more contentious is the use of anti-HBc testing. A study of post-transfusion non-A, non-B hepatitis in 481 recipients by Harvey Alter and associates at NIH showed (*Annals of Internal Medicine* 104, 488; 1986) that 11.9 per cent developed non-A, non-B hepatitis after receiving blood from donors positive for anti-HBc, compared with 4.2 per cent among recipients for blood negative for anti-HBc.

Alter estimated that prospective anti-HBc screening could eliminate 43 per cent of non-A, non-B hepatitis cases, while losing only 4 per cent of donors. Joseph Bove, chairman of AABB's committee on transfusion-transmitted diseases, argues that, taken with ALT screening, anti-HBc will go a long way towards reducing non-A, non-B hepatitis. Bove also argues that anti-HBc will be a useful "second line of defense" in screening for hepatitis-B. But Bove admits that there is no good biological reason to explain why people with antibodies to hepatitis-B core antigens should be more likely to transmit non-A, non-B hepatitis. The same positive relationship does not exist between hepatitis-B surface antibodies and transmission of non-A, non-B hepatitis.

Robert AuBuchon of the American Red Cross says the Red Cross is planning to start an anti-HBc screening programme of its own, but not until after the ALT test is implemented. Counts feels that the Food and Drug Administration should play a larger role in certifying the usefulness of anti-HBc. Counts also points out that Alter's study used a radioimmunoassay for anti-HBc testing, whereas an enzyme-linked assay is more likely to be utilized in a large screening programme. A further concern is that once implemented, screening tests are hard to dispense with. The Red Cross had planned a prospective clinical trial of non-A, non-B hepatitis screening techniques, but were daunted by the size of the project, and the possible ethical problems of giving unscreened blood to recipients.

What everyone is hoping for is a direct test for the agent causing non-A, non-B hepatitis, but that seems a long way off. Several candidates have been suggested, but none has held up. A major hurdle is tracking down the causative agent is its low concentration in blood — as much as 10,000 times less than hepatitis-B virus — and the lack of a suitable animal model for the disease. Only chimpanzees have been successfully infected with non-A, non-B hepatitis.

A major concern for all blood centres will be the loss of donors from false positives from the ALT and anti-HBc tests. Between 4 and 7 per cent of donors are expected to be prevented from giving blood. This comes at a time when screening for antibodies to the AIDS virus has already had a negative impact on the blood supply. The test will also increase the cost of a unit of blood by about \$3. Despite the additional cost and the loss of donors, AABB president Eugene Berkman says the tests are "essential to increase the safety of the blood supply".

Joseph Palca

Good prospects for lion tamarins

Washington

BRIGHTER days may lie ahead for the golden-headed lion tamarin (*Leontopithecus chrysomelas*). The National Zoo here in Washington recorded the first birth last



Jessie Cohen, National Zoo

month in a captive breeding programme established to restore numbers of the endangered species.

Golden-headed lion tamarins have recently been the object of a worldwide conservation effort (see *Nature* 322, 586; 1986). The Washington infant's parents are themselves well travelled. They were part of a group of 16 golden-headed lion tamarins imported by a Belgian animal dealer in the winter of 1983 just before Belgium signed the Convention on International Trade in Endangered Species. The animals were ultimately repatriated to Brazil in November 1985 but were not released into the wild. Instead, an International Recovery and Management Committee for the tamarins, co-chaired by Jeremy J.C. Mallinson of the Jersey Wildlife Preservation Trust and Ademar Coimbra-Filho of the Rio de Janeiro Primate Center, decided that the animals should be included in a captive breeding programme to be conducted both in Brazil and at several locations in North America.

Last March, a total of 20 golden-headed lion tamarins, including the 16 recovered from Belgium, were sent to the National Zoo in Washington and the Los Angeles Zoo. The National Zoo subsequently sent four animals to the Brookfield Zoo in Chicago. Under the terms of the breeding programme, all the US animals remain the property of Brazil, and may some day be included in a programme to reintroduce them to their natural habitat.

Devra Kleiman of the National Zoo, who is a member of the international management committee, says that until there is a better monitoring programme for wild golden-headed lion tamarins, it would be a mistake to release the captive population. In addition to the one birth, two other tamarins at the National Zoo appear to be pregnant. "Consider these as genes in the bank", says Kleiman.

Joseph Palca

Cameroon disaster

Carbon dioxide blamed

Washington

US INVESTIGATORS at Lake Nios, Cameroon, where 1,700 people were killed by toxic gases on 21 August, believe the disaster was similar to one that occurred in Lake Monoun, also in Cameroon, in 1984, which killed 37 people, according to the State Department Office of Disaster Assistance. There it is thought large quantities of carbon dioxide were released from the lake bottom. Both lakes are set in deep craters, and if the parallel proves correct there could be important implications for geochemically similar lakes in the area, including Lake Kivu.

Among the teams sent from the United States are limnologists, geochemists, pathologists and volcanologists. Also in Cameroon is Harold Sigurdsson of the University of Rhode Island, who studied the Lake Monoun event. He and his colleagues concluded that carbon dioxide, possibly contaminated with other unidentified gases, was released following a disturbance of the lake bottom triggered by a landslide, perhaps caused by a minor earthquake. The carbon dioxide is thought to have slowly seeped from cold volcanic vents and accumulated over many years in high concentration, partly as bicarbonate, in the hypolimnion, along with ferrous ions reduced from siderite deposited in the lake by wind-blown loess. Nucleation points for the saturated solution were provided by the bottom disturbance and the gas came out of solution. Sigurdsson estimated that carbon dioxide was present in the hypolimnion at a pressure equivalent to 10 atmospheres; carbon-14 analysis showed 90 per cent of the carbon to be of volcanic origin.

Some observations of the bodies both at Monoun and Nios suggest that other gases may also have been present. Some descriptions speak of reddish skin burns and foaming at the nose and mouth that would not have been caused by carbon dioxide. Vegetation was also bleached, although clothing was unaffected. Sigurdsson and colleagues excluded sulphuric acid from oxidised hydrogen sulphide as a cause because it was virtually undetectable on the lake and because sulphuric acid usually causes black, rather than red, skin burns. Nitric acid may have been formed from oxidation of ammonia. The US teams will be taking samples from the water at different depths as well as from the atmosphere, and measuring temperature profiles. Pathologists may exhumate some bodies for examination; details will be presented to the US ambassador in Cameroon sometime this week or next.

Tim Beardsley

Museums

Science with a touch of magic

WHAT is Richard Gregory, head of the Brain and Perception Laboratory at the University of Bristol, doing bent over a snooker (pool) table? And how is it he never misses a shot?

Closer inspection will reveal that he has given himself an advantage — the inside of the table is elliptical. That means that if two balls are placed at the foci of the ellipses, the two will always collide whatever direction you hit one of them in.

The snooker table is one exhibit from Gregory's new museum, the Exploratory,

planes) up in the air.

Then there is a set of mirrors to lead you to a solution to the old paradox of why you look left/right reversed in a mirror but not upside-down. The answer is simple and difficult — according to Gregory, among those who have it wrong are Plato, Lucretius and Kant (and Martin Gardner in *The Ambidextrous Universe*.) The "exploratory" answer: that mirrors allow us to see the front of opaque objects although we are behind them: and the reversal is produced by the rotation of the object to face the mirror. You can try it with a book in front of a mirror: turn a page facing you to face the mirror either by turning it around or by turning it over. The latter produces no left/right reversal.

Dozens of exhibits force even trained scientists to think twice. Among them, Gregory himself is as excited as if he too is seeing them for the first time.

But how are children going to react? The full-size 20,000 square foot "Exploratory — Hands on Science Centre" will be receiving several school parties every day. Will they too recognize that "science has its own magic"? The Exploratory's director, James

Dalgety, who has spent the past fifteen years running a puzzle-manufacturing company, admits to few doubts.

Alun Anderson



which will open next month and from which a selection of exhibits are being previewed at this week's meeting of the British Association for the Advancement of Science in Bristol. Other than the Exploratorium in San Francisco, there is nothing quite like the new museum. It is a place for people to explore: it is not exhibits that do things when people press buttons, but people who do things with the exhibits until explanations emerge.

Many exhibits excite interest by producing effects that are counter-intuitive. For example, two tracks down which model cars can be run have been set up on one wall. One track is straight, the other curved. How many people will be willing to bet that the car on the curved track will reach the finish faster than that on the straight track? And how many believe that if you start a pair of cars off at different points on the curved track they will always arrive at the finish simultaneously wherever you start them from?

Elsewhere, a ball hovers six feet up in the air. It is suspended on a jet of air — no surprise until you see that the air jet is several feet away. Why does the ball not just drop out when the air stream is bent to one side? Some balls dangling on strings nearby and an ordinary hair-dryer give one a chance to explore the Bernoulli effect which keeps the ball (and aero-

• While Bristol's hands-on science exhibition concentrates on brain teasers, London's equivalent is more attuned to catching the imagination of the younger visitor. Under development for several years, "Launch Pad" was officially launched last week at the Science Museum. Most of the 70 exhibits are geared more to technology than to science. And the designers have usually chosen to provide a simple illustration of a principle rather than to set a problem.

Among the exhibits that may already have provided the formative experience for the next generation of technologists is the arch bridge: five blocks are arranged on supports to form the arch, the supports are removed and the builder is persuaded to walk over the bridge.

Where problem-solving is in evidence, it is likely to be in the form of assembling a lock and key or water pump from large parts in a transparent casing. The joke exhibit is a standard hot air hand-drier, an adjunct to the several popular exhibits that involve contact with water. Among these is a giant simulated toilet cistern and a miniature flow tank. Peter Newmark

Nuclear power

India's reactors run into trouble

New Delhi

INDIA'S RAPP-1 nuclear-power reactor in Rajasthan state seems set to gain an unenviable world record as the first reactor to be prematurely retired. It has been in service for just eight years.

The Canadian-built 230 MW (E) pressurized heavy-water reactor has been out of action since March 1982 following detection of a crack in the end-shield of the reactor vessel. A four-year battle, using remote-controlled tools, failed to plug the leak in a highly radioactive and inaccessible area which, according to Dr M R. Srinivasan, chairman of the nuclear power board, "has become embrittled by radiation". The only options now are an expensive operation to replace the end-shield after a long wait to "cool" the reactor, or a permanent close down of the £110 million reactor. According to nuclear engineers, closing down for good will be more economical.

More bothersome to India is the problem that has crippled the 100-MW (thermal) Dhruva reactor in Trombay, a key facility for producing plutonium. The high flux, £60 million reactor which went critical last August, was expected to generate about 60 kilograms of plutonium annually. But Dhruva has dashed India's hopes of producing and stockpiling plutonium because a design flaw prevents the reactor operating above 20 MW.

Dhruva, which uses natural uranium as fuel and heavy water as coolant and moderator, is a bigger and improved version of the Canadian-built 40-MW (thermal) reactor Cirus which supplied the plutonium for India's nuclear test in 1974. One major difference is that being a production reactor, Dhruva's fuel pellets are clad with aluminium (instead of the usual aluminium-zirconium alloy) to make reprocessing of plutonium easier. It is not known if the choice of aluminium for cladding and coolant tubes was a mistake. According to Dr P K. Iyengar, director of the Bhabha Atomic Research Centre (BARC), Dhruva could not be operated at high power levels because of excessive vibration of the coolant tubes when heavy water was pumped through them under pressure. The vibrations could lead to rupture of the fuel rods inside the coolant tubes which would contaminate the coolant with fission products.

BARC has been trying to solve the problem for the past eight months and has now decided to dampen the vibrations by placing clamps at intervals along the fuel rods. According to Iyengar, simulated runs after partially loading the reactor with modified fuel bundles have shown satisfactory performance. But the question of whether the clamps will provide a

permanent solution will be answered only in actual operation. Similar vibration problems also cropped up in the Superphénix reactor in France according to Iyengar, who hopes that Dhruva can begin operation in a month.

Recommissioning of Dhruva is vital for India's goal of accumulating sufficient stocks of plutonium to fuel its breeder reactors in the second phase of its power programme. The 25-year-old Cirus, the only other plutonium-producing research reactor, is operating at half its capacity and is due for decommissioning. India has the means to reprocess plutonium from spent fuel, but international agreements

prevent it from doing so at four of its six power reactors. The United States has not permitted India to reprocess fuel from the two American-built reactors in Tarapur.

India has been reprocessing the fuel from the two 230-MW reactors in Rajasthan, RAPP-1 and RAPP-2, but an agreement with the Soviet Union (which supplied heavy water) forbids India from diverting the processed plutonium to any unrestricted facility. In a major move to overcome this restraint, BARC has now decided to burn the plutonium along with thorium in RAPP-2 itself. By conserving natural uranium, which is scarce in India, BARC says its strategy will help use the plutonium. India is free to use the plutonium processed from its power reactors in Madras but reprocessing of fuel has not yet begun.

K S. Jayaraman

Environmental protection

Ice-minus test stopped yet again

Washington

THE first field test of bacteria that have been genetically engineered to protect plants against frost damage will not, after all, take place this year. The University of California, which is proposing the test, last month agreed with opponents that it would re-examine safety issues before going ahead. Because the test cannot be performed during the winter months, it is now unlikely to take place before next spring.

The test was first proposed by Steven Lindow of the University's Berkeley campus in 1982. Lindow plans to spray potato plants with a genetically altered strain of *Pseudomonas syringae* that has had removed the gene responsible for producing an ice-nucleating protein. Because the protein in naturally occurring *P. syringae* acts as a focus for ice crystal formation on host plants, Lindow hopes that the engineered form will reduce frost damage.

Lindow's experiment has already been the subject of environmental impact assessments and formal approval by two federal agencies, the National Institutes of Health and the Environmental Protection Agency. But earlier this month, local groups, together with Jeremy Rifkin's Foundation on Economic Trends, obtained a temporary restraining order against the university on the grounds that it may not have met the requirement of Californian law for a local environmental impact report if any significant impact is thought plausible.

The out-of-court agreement now reached obliges the university to review all the safety evidence once again and to decide within 30 days if a local impact report is indeed needed. But the plaintiffs have also agreed to provide any new evidence they want taken into account, and if they disagree with

the university's assessment have only a further 30 days in which to sue. Lindow says he hopes that the deal will mean that there will be no more last-minute hitches. Numerous and expensive preparations for the experiment had to be abandoned when the temporary restraining order was issued on 4 August, just 2 days before the test was due to start.

Tim Beardsley

Sun shines on UN's Kabul venture

UNITED Nations funds are helping to set up a new research and development centre for solar energy in the Afghan capital of Kabul, according to the official news agency Bakhtar. The foundation stone was laid on 5 August and construction is due to be completed by 1990.

Facilities are to include production workshops, laboratories, showrooms, small water stations, greenhouses, small animal husbandry farms, poultry rearing and a "typical biogas plant". Equipping the centre, and the training of "technical cadres" is expected to cost some US\$1.2 million. When completed the centre should meet the "energy needs of the people for lighting and heating of buildings, water supply and cooking".

This major UN investment represents a new phase in Afghanistan's development. Until the socialist "Sowr revolution", the principal source of foreign investment was the United States which, for example, had plans to develop at Kandahar the largest airport in Asia. Since the Soviet "fraternal intervention" of December 1979, the main source of aid has been the Soviet Union, which has provided the funds for facilities ranging from primary schools and hospitals to a sophisticated new broadcasting centre.

Vera Rich

RGO move FAR from OK

SIR—Your correspondents in the somewhat unfortunately titled letter "RGO move OK" (*Nature* 322, 402, 1986), claim that *Nature* does not fully realize the implications of the move of the Royal Greenwich Observatory (RGO) to Cambridge. This shortcoming is clearly not unique.

They state that the move to Cambridge will consolidate research astronomy with instrument science and engineering. Yet this ignores both the stated policy of SERC and its recent history in directing the affairs of RGO.

When many people now working in high technology at RGO were recruited, they joined a national observatory in its own right. The research programme was then considered an important part of the life of the observatory, while traditional long-term projects were considered of value and were pursued vigorously. Although instrumentation at that stage had not kept up with the other work, a very positive environment allowed and encouraged the introduction of the advanced instrumentation and engineering techniques essential to an international class observatory.

Over the past few years, however, SERC has sought to erode this by a process of attrition: it has restricted the astronomical research role to ten per cent of manpower effort, it has continually cast doubt on the long-term projects being carried out here, and now, in its current forward look, it has established firm plans to cut severely the applied science and engineering aspects of the work. The result will be that manpower allocated to this area in 1990 will be around one-third of its 1982 level, of which a significant fraction will be allocated to La Palma for maintenance support. Clearly the capability of RGO in 1990, particularly in instrumentation and technology, will be nothing like as great as it is today.

It has been stated by SERC that the move must be self-financing. This can be achieved only by selling the Herstmonceux site, which is immeasurably more valuable to SERC than its sale price can possibly be. Even then, the move cannot be made self-financing without cutting manpower dramatically or greatly reducing the facilities available. It appears that SERC plans to follow both courses of action and will impose a burden on the university to make up for the shortfall in support.

This curious view of economics by SERC is not confined to RGO. The recent withdrawal from the South African Astronomical Observatory and near-withdrawal from the Anglo-Australian Observatory (AAO) have similar implications. Had the AAO withdrawal occurred (and the agreement must still be consi-

dered under threat), SERC would have spent about £30 million on La Palma without any significant corresponding increase in the observing time available to UK astronomers. The generosity of SERC in providing capital facilities, which you so rightly mention in your leading article of 3 July (322, 1, 1986), could surely have been put to better effect when considering the resources necessary to run those facilities that already exist.

What makes the prospect of a move to Cambridge so dismal is not just the upheaval and waste of effort involved, but the fact that there will be no change in style of management by SERC. There will be the same unwillingness to state aims and to provide the resources to execute those aims (or to reduce them correspondingly), there will be the same cavalier attitude to staff morale, there will be the same excessive concentration on capital facilities at the expense of running existing facilities to produce science.

It therefore seems likely that what the University of Cambridge expects and what it receives will not correspond.

We strongly urge the chairman and council of SERC to reconsider their decision in order to minimize the serious damage already done. Perhaps we could then sit down together, in the democratic manner that you mention in your leading article, and discuss long-term aims that would offer British astronomy the best prospects for the future, council's plans clearly do not do that at present.

I G VAN BRED A & P D READ
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SIR—Contrary to your headline-writer's caption to the letter (*Nature* 322, 402, 1986) about the proposed move of the Royal Greenwich Observatory (RGO) to Cambridge, the RGO move is NOT OK. The move to Cambridge is merely the least of several evils—but the Science and Engineering Research Council (SERC) may also have miscalculated the cost.

The rumour mill suggests that the cost of moving RGO is roughly £6 million and SERC claims that the move can be self-financing. However, cursory research will uncover various press articles on the current slump in the price of castles (see, for example, an article in the *Sunday Times* of 13 July). Apparently "Fort Belan, an 18th century fort complete with cannon, drawbridge and ramparts guarding the Menai Straights in North Wales has still not found any takers (although it has been offered) complete with an airfield, three miles of coastline and a dockyard for £750,000."

Agricultural land, the property associated with Herstmonceux Castle, is at its lowest value for years, partly due to changes to the agricultural support policies of the European Communities and partly amplified by the dumping of land by city speculators. I conclude that it is highly improbable that the sale of the castle will fetch much more than £0.5 million. I fear that SERC will be committed to the move before its illusions about the value of the Herstmonceux site are shattered. Having to find £5 million will pauperize UK astronomy and further reduce SERC's funding of other sciences.

Either SERC must experimentally establish the value of Herstmonceux Castle by putting it on the market before it takes irrevocable steps or the Treasury must reject this "self-financing" proposal as based on an untested theory. Factor-of-ten errors may be acceptable in astronomy but not in the financial provision for it.

MICHAEL PENSTON

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Fish-eating Eskimos?

SIR—Your Washington correspondent Tim Beardsley's account of the US nutritional research scene¹ refers to the "low rate of heart disease among Eskimos who eat a lot of fish." But of the sixteen major Eskimo groupings in the western Arctic zone², only three (Aleut Eskimos, Southern Alaskan and Western Alaskan Eskimos) ingest fish as a portion of their daily diet. Most consume lipids of marine mammalian origin.

The beneficial effects of omega-3 polyunsaturated fatty acids derived from marine sources were reported by Dyerberg's group^{3,5} based on their studies on Greenland Eskimos who predominantly consume whales and seals, but not fish. Bang *et al.*³ reported that the frequency score of meals (average number during one week's consumption) eaten by Greenland Eskimos decreased in the following order, seal meat and blubber 6.4, whale meat and blubber 5.7, soup with seal meat 2.3, fish 1.4, and seal intestines 0.6. It is also interesting to note that the word Eskimo is apparently derived from a Cree Indian word, meaning "eaters of raw meat."

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Have the heavy neutrinos gone?

▷ *The pursuit of particle physics without the use of accelerating machines is always an intriguing challenge. But the simplicity of measurements may be offset by complications of interpretation.*

THE search for the heavy neutrino continues, but the chances of success seem steadily to diminish. That is the curious psychological effect of a demonstration, just published, of the pitfalls ahead of those who look for evidence of heavy neutrinos (where "heavy" merely means "greater than zero") in the electron spectrum associated with beta-decay.

The argument, due to J. Lindhard and P. G. Hansen from the University of Aarhus in Denmark (*Phys. Rev. Lett.* **57**, 965, 1986) is interesting not so much because it is decisive, but because of its simplicity and clarity. Its bearing on the question whether neutrinos can have even a modicum of mass is only indirect.

The idea that neutrinos may have mass is now some 15 years old. The successful unification of the weak and the electromagnetic force-fields implies that there should be as many kinds of neutrinos as there are different kinds of electron-like particles, which for the time being means three (the tauon and muon with the ordinary electron). The notion that some neutrinos may have mass arises from attempts to unify strong and weak nuclear forces.

Cosmologists do not bother to conceal their delight at the prospect that a nearly universally distributed particle might carry enough mass to help close the Universe gravitationally. Everybody seems to agree that, if there are indeed three kinds of neutrinos with very similar properties, those actually observed will be mixtures (in the quantum sense of being linear combinations of fundamental states) of the three basic neutrinos. Specifically the neutrinos (strictly, anti-neutrinos) emitted in partnership with electrons during beta-decay will on the average carry a fraction of any mass there may be.

This was the inspiration of an accurate measurement 10 years ago by Soviet physicists of the energy-spectrum of electrons emitted in the beta-decay of tritium. The point is merely that if the associated neutrinos have even the smallest amount of mass, the requirement that energy and momentum should be conserved in the decay will distort the energy spectrum that would otherwise be expected.

As neutrinos as such cannot be observed directly because they hardly interact with matter, the predicted distortion of the electron energy-spectrum may offer the best hope, for the time being, of measuring their properties. A quick calculation will show that there will be a ten-

dency for an excess of electrons at low energy.

Tritium is an obvious place to start, if only because the transition energy is relatively small and because the effect on the decay process of the atomic electron shell can be calculated easily, given the simplicity of the structure. But the same search for distorted energy spectra has been carried out with the isotopes ^{64}Cu , ^{35}S and no doubt others.

Most experiments have yielded only inconclusive evidence. Datar, V. M. *et al.* (*Nature* **318**, 547, 1985), for example, working with ^{35}S , found that the admixture of a single supposedly massive neutrino corresponding to, say, a muon with the supposedly zero-mass electron neutrino would be, at most, a mere 1 per cent.

The outstanding result in the field remains that of J. J. Simpson, from the University of Guelph in Ontario, who has studied tritium decay by a neat technique in which tritium atoms are embedded in a silicon detector that functions as a means of measuring the total loss of energy by ionization within the silicon, for which purpose the semiconductor is doped with lithium (*Phys. Rev. Lett.* **54**, 1891, 1985).

Simpson's conclusion, going against the grain of earlier evidence except that from the Soviet Union, is that the energy spectrum of the decay electrons does indeed differ from that expected on the simplest principles, and in such a way as to suggest that the massless neutrino is mixed to the extent of 3 per cent with a heavier neutrino whose mass is the equivalent of approximately 17.2 keV. Ungratefully, even cosmologists are not enthusiastic this neutrino is embarrassingly massive.

Lindhard and Hansen make one elementary point about Simpson's experiment, that it differs from most others of this kind in that the decaying tritium nuclei embedded in silicon are mostly stripped bare of their single electron. It follows that the decay energy is not the conventional 18.6 keV, the difference of energy between an atom of tritium (with one electron) and an atom of its decay product, ^3He , which has two electrons.

Most simply, what this remark implies is that the energy available in the decay of a stripped tritium nucleus is less than that which might be wrung from the decay of an intact atom by the difference between the absolute values of the two ground-state electron energies, both negative (of which that of helium is larger to the tune of

more than 65 eV). But to say that the energy available will be different for the decay of a stripped and for an intact atom does not imply that all the difference will be conferred on the decay electrons, although the magnitude of the effect is such as to suggest that Simpson's small differences could easily be swamped.

What Lindhard and Hansen have done is to make qualitative calculations of how the difference of available energy between stripped and intact atoms will be reflected in the energy spectrum of the electrons. The most obvious influence is that of the atomic electron in an intact tritium atom, which will have the effect of increasing the outward energy of the electron. Other effects of the atom on the departing electron are more subtle.

The fact that the sudden conversion, in beta-decay, of a tritium nucleus to a helium nucleus leaves the lone electron in an excited state implies that some part of the 18.6 keV difference of energy between the two ground states is released not to the electron or neutrino, but in de-excitation. Similarly with the deionization that must follow that adjustment. Note that the term "sudden" is not merely descriptive but is a technical term in quantum mechanics.

The calculation of the quantities involved is unavoidably messy, that for the screening correction was first done by M. E. Rose in the 1930s. Lindhard and Hansen add a nice twist by using a function to represent the screening potential of an electron shell that includes an exponential term yet nevertheless allows for exactly soluble wave functions.

The upshot is the conclusion that the energy carried off by electrons will be decreased, on the average, by some 34 eV, or that the expected electron energy spectrum calculated from the full value of 18.6 keV will be shifted bodily towards the origin of energy by that amount. This, the authors claim, is enough to account for two-thirds of the discrepancy claimed by Simpson. Chemical interactions, weighing in on the same side as de-excitation and deionization, could account for the rest.

There is no logical reason why this should strengthen beliefs that massive neutrinos do not exist. The theories are explicit on the point, while there are many other types of experiments in which the issue may be tested. But there is a sense in which negative trials of a hypothesis count positively against it: many people are prejudiced against failure.

John Maddox

Cell biology

Is there a common design for cell membrane channels?

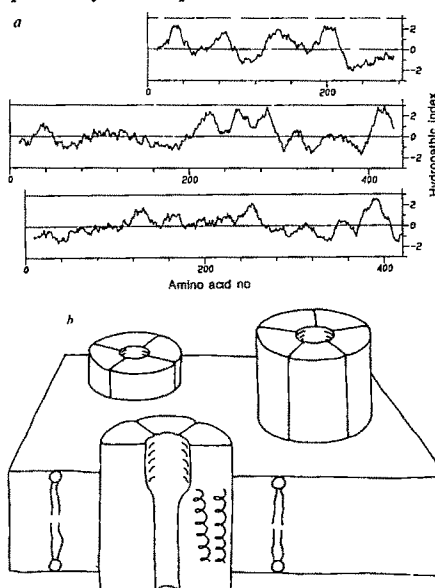
from Nigel Unwin

THE first membrane channels to be seen clearly in electron-microscope images were those at gap junctions, described by David Robertson¹ a little more than 20 years ago. The molecular characterization of these channels has recently taken an important step forward, as the primary sequence for a gap-junction polypeptide, reported in two of the latest issues of the *Journal of Cell Biology*^{2,3}, has now been deduced from complementary DNA clones. This accomplishment follows closely the analyses in Shosaku Numa's laboratory of the voltage-dependent sodium channel⁴ and the subunits of the nicotinic acetylcholine receptor⁵, making a total of three eukaryotic cell membrane channels whose sequences have been derived by recombinant DNA methods. Intriguingly, all three channels are major participants in the transmission of electrical signals in excitable tissue. Given that they are functionally related, although individually quite distinct, is it possible that they are all simple variations of a common structural theme? Several hints, or analogies with other systems, suggest they could be.

First, the new details about gap junctions. In David Paul's experiments² the cDNA encoding a gap-junction polypeptide was obtained by screening a rat liver library with an antibody specific to the gap junction, whereas Nalin Kumar and Bernie Gilula³ used a human liver library and a synthetic oligonucleotide probe based on the previously determined amino-terminal sequence⁶. In either case, the derived primary sequence corresponds to essentially the same polypeptide (only 4 residues difference between human and rat), which has a relative molecular mass of 32,000 (32K). This polypeptide contains no amino-terminal signal sequence and may correspond exactly to the channel subunit normally detected on SDS gels as a 28K band, although there could, for example, be post-translational cleavage of a carboxy-terminal domain. The three-dimensional structure of this polypeptide, when the time comes, will be doubly interesting: not only must it assemble an ion channel in the membrane of one cell, but also it needs to link tightly to a channel in the neighbouring cell so that the pair together create a continuous, leak-proof communication pathway between the cell interiors.

To those of us who have scrutinized hydropathy profiles for the subunits (or domains — see below) of the other two

channels, the profile for the gap-junction polypeptide (*a* in the figure) looks remarkably déjà-vu. In common with the other channels, there are several strings of hydrophobic amino acids around 20 residues long. Such sequences are uncharacteristic of soluble proteins, but probably correspond to transmembrane



By accident or design? *a*, Similar hydropathy profiles¹² (19-amino-acid window) for the rat liver gap-junction polypeptide (top), α -subunit of the acetylcholine receptor (middle), and amino-terminal portion of sodium channel containing the first homologous domain (bottom). *b*, Diagram emphasizing the apparent structural similarities of the three channels.

α -helices, as direct sequence and structural comparisons of the L and M subunits of the photosynthetic reaction centre convincingly demonstrate⁷. Alpha-helical models for the acetylcholine receptor and sodium channel have been derived on this assumption and clearly the implication now is that the transmembrane portion of the gap-junction polypeptide also contains several α -helices. Thus I think that the original ' α -helical' interpretation of the X-ray scattering pattern from isolated gap junctions⁸ is closer to the truth than the ' β -sheet' interpretation quoted in ref. 2. Indeed, it looks as if the α -helical bundle is a structural motif common to the bilayer portion of all the channels, whatever the specialized features required to meet their specific physiological needs.

A fundamental aspect of molecular design is the symmetry. For each of the channels the symmetry has either been evaluated experimentally or (in the case of

the sodium channel⁴) deduced from the sequence. The molecules each consist of like units arranged in the plane of the membrane around a central aqueous pathway, the pore. The gap-junction channel is made from a ring of six identical subunits, the acetylcholine receptor from a ring of five similar (including two identical) subunits, and the sodium channel from a ring of four similar domains composing about 60 per cent of a single polypeptide chain. Evidently the gap-junction channel is the only channel with true rotational, or cyclic, symmetry, however, the amino-acid homology between the similar subunits (about 40 per cent) or between the similar domains (about 50 per cent) is certainly high enough to imply that the corresponding tertiary and secondary configurations are largely the same. Hence the respective structures would be expected to have good symmetry at this level over much of their length, as is indeed suggested by direct images of the acetylcholine receptor⁹.

Thus, all three channels apparently possess cyclic symmetry, or a very good approximation to it, the symmetry axis delineating the pore through the membrane (*b* in the figure). Is this common architectural plan reflected in other features? Considering the parallels noted in the internal structure of the proteins, it may be no coincidence that the constricting diameters of the pores — about 16 Å for the hexamer (gap junction), about 7 Å for the pentamer (acetylcholine receptor) and about 4 Å for the tetramer (sodium channel) — vary in proportion, qualitatively, with the number of elements around them. It is also interesting that the pores of the gap-junction channel and acetylcholine receptor seen in electron-image maps^{9,10} are of the same character, constricted at one end (cytoplasmic) but wide open for an extended length at the other. As for the implications, perhaps the similar structural patterns are clues that the channels respond to chemical or electrical stimuli by related mechanisms. Except for the energetic constraint that subunit displacements should be predominantly parallel, rather than perpendicular, to the plane of the bilayer, there seems to be no reason why the rules should not be much the same as those for a soluble multi-subunit complex, such as haemoglobin.

Simple variations of a common structural theme occur frequently in nature. The protein shells of spherical viruses as diverse as those which infect plants or give us colds are, it turns out, such an example (see the recent discussion in *News and Views*¹¹), and may represent the type of assembly to which the channels are most analogous. Tomato bushy stunt virus, for instance, like the gap-junction channel, is constructed from multiple copies of the same polypeptide, human cold virus, like

the acetylcholine receptor, is constructed from different but related major polypeptides, satellite tobacco necrosis virus is constructed from one species of polypeptide, but is a smaller virus, having a third as many copies as the others. The striking discovery to emerge from a series of outstanding X-ray crystallographic studies conducted over the past few years is that the structures of the major polypeptides of all these viruses are very similar. Animal or plant virus, big or small, the basic motifs are much the same.

Urgently needed now from at least one of these channels is high-resolution information of the sort obtained from the viruses. Substantial technological advances have been made in macromolecular crystallography and membrane protein crystallization over the past few years, so it should not be too long before that dream is realized. The details revealed would provide a three-dimensional framework for rational site-directed mutagenesis experiments and other studies aimed at

probing precise physiological functions. They should also yield important insight into the general structural principles involved in switching between open, closed and inactivated (or desensitized) states. Contrary to the impression given by the variety of current models, it could be that all membrane channels work in much the same way. So far, at the junction between structure and function, there is a bit of a gap! □

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Optical computing

Elements of an optical engine

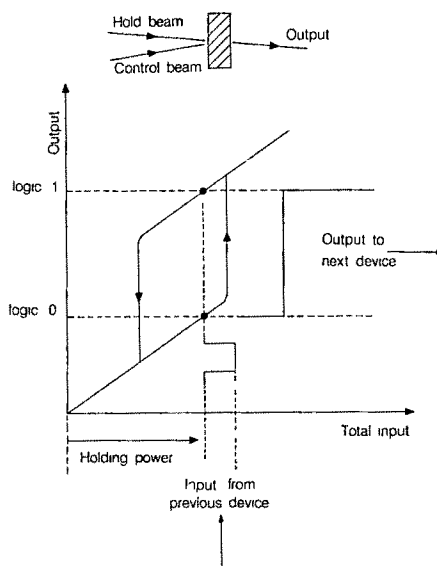
from Alan Miller

CAN the massive parallelism across an image and speed of light be harnessed to create a computer to compete with an already highly developed electronics technology? Two recent announcements bring an answer considerably closer. Heriot-Watt University in the United Kingdom and AT&T Bell Laboratories in the United States have now both demonstrated early cascable bistable arrays — an essential requirement for digital optical parallel computing.

Digital optics is at an early stage of development, but the goal of both groups is to develop the technology required to demonstrate that optics can make a significant impact in digital processing and computing, rivaling silicon or gallium arsenide circuits in specific applications when and where electronics becomes limited. The advantage of optics is that whereas electrons interact strongly with each other, photons pass through each other unperturbed in the absence of any nonlinear interaction. This makes light a powerful, low cross-talk, high bandwidth means of interconnecting devices in parallel by using holograms, fibres or simply novel geometrical optics, which is beginning to be exploited for computers. But to go beyond mere communication and create an all-optical processor, optical logic and memory have had to be developed.

The first semiconductor optical equivalents of the transistor were demonstrated seven years ago in simultaneous research

at Heriot-Watt University¹ (using InSb) and at Bell laboratories² (using GaAs) that exploited newly discovered band-gap resonant, giant optical nonlinearities in semi-conductors³. By applying optical feedback in the form of reflecting mirrors



An optical logic element depends on a 'hysteresis' between input and output light. With the element in its opaque (logic '0') state, a hold beam keeps the device close to a transition to transparency (logic '1'). A small input signal can then flip the device through the transition and let the hold beam through. For cascable arrays the power thus transmitted must be intense enough to act as a switching beam in subsequent elements.

on either side of the nonlinear crystal (often just the reflecting surfaces of the semiconductor), all-optical bistable or memory devices (see figure) were achieved that need only a few milliwatts of optical holding power⁴. All-binary logic operations have since been demonstrated. Optical bistability in other semiconductor materials has been actively pursued in various laboratories in the United States and Europe.

Successful implementation of these devices in digital optics will impose stringent requirements on their operation, including stability and reliability, low-power operation at relatively high speeds, good contrast between low and high states, and the ability to pack arrays of devices densely. Any one logic element must be able to accept inputs from several other devices (fan-in) and be able to communicate its output to several more (fan-out). The cascability of elements depends on the gain of the device, that is, the ratio of the change of throughput of the holding beam, to the additional input above the holding power required to switch (the holding beam functions as the power supply).

The group at Heriot-Watt had previously demonstrated cascability by sequentially coupling the output of one InSb device to the input of a second device on the same crystal such that the combination gave an XNOR gate⁵. Its recently announced work, which goes as far as producing the first cycling logical machine (the guts of a computing engine) forms part of the Joint Optical Bistability project (EJOB) supported by the Commission of the European Communities. EJOB links 12 laboratories with the aim of demonstrating a primitive optical computer. Under this scheme the Heriot-Watt group has now demonstrated an optical circuit consisting of three separate ZnSe bistable plates positioned in a loop such that green beams from an argon-ion laser can be passed from one plate to the next around the loop. Holographic elements divide the beams into arrays of three spots on each plate while signal and clocking pulses are provided by acousto-optic modulators. This shows the transfer of data, in parallel, around a processing loop in a 'lock and clock' sequence, an inversion occurring on each full cycle of the loop — essentially the primitive cycling computer that is the aim of EJOB.

The bistable plates, the essential nonlinear optical elements used for this demonstration, are thermally evaporated, multilayer band-pass interference filters containing ZnSe as the nonlinear spacer layer⁶. Optical bistability at a few milliwatts is achieved by thermally induced refractive index changes. These devices have the appeal of being relatively easily constructed with a high degree of uniformity over large areas, although some

stability problems need to be overcome

In contrast, the Bell laboratories work, announced at a conference on lasers and electro-optics in San Francisco this June, requires very high-technology, ultrathin multilayers of GaAs and GaAlAs, each only a few atomic layers thick, grown by molecular beam epitaxy to a total thickness of a few micrometres⁶. The Bell group used an electro-absorption effect so the feedback necessary to achieve optical bistability is electrical instead of all-optical, the arrangement is therefore hybrid. The novelty is that the electrical feedback is intrinsic to the device, as the material acts as both photoconductor and optical modulator, so only a constant electrical bias need be applied. Furthermore, a built-in bias resistor is controlled by an auxiliary light source.

By making use of the anomalously large electric field shift of a quantized exciton in GaAs layers less than 100 Å thick (quantum confined Stark effect⁷), the Bell group showed optical bistability could be achieved at between 1 mW and 1 pW in the 834–859 nm range in these self-electro-optic effect devices (SEEDs). The relatively low switching powers are traded, however, for switching speeds in the range 1 µs to 10 s by altering the bias conditions with a He–Ne laser. A 2×2 array was made by etching 200 µm square mesas. Improvements to the performance of these devices allowed more than a 2.5:1 contrast ratio with a high degree of uniformity over the four devices, thus offering cascability in devices compatible with existing GaAs optoelectronics technology.

Both these examples of cascable arrays use devices that need much more refinement in terms of number of elements, speed and energy consumption before they could be practical, but it is worth bearing in mind that even a 100 × 100 array of devices switching at 1 µs would offer an impressive 10¹⁰ gate switches per second. What these demonstrations do prove is that semiconductor components for photonic switching and digital parallel processing now exist. Both can be readily scaled to accommodate larger numbers of elements offering test beds for exploring innovative ideas on architectures most suitable for parallel

arrays of gates

The first applications of these optical switches may well come from routing in fibre communications where the input from many thousands of fibre channels is already in a highly parallel form. Optical switching arrays in a pipelined sequence could route data using coded pulses, thus avoiding the intermediate conversion to electronics which will become increasingly more difficult as the operating frequencies

increase¹⁰. The algorithms used in this application are not too far removed from many computing operations. Other applications appropriate to parallel processing would be, for instance, image processing, machine vision and radar array processing, which are already stretching electronic systems to their limits. □

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Plant ecology

Counting the costs of rainfall

from Peter D. Moore

PRECIPITATION brings both benefits and problems to the plant life of an ecosystem, as demonstrated by several recent reports. Rainfall provides a source of nutrients which may be critically important to the recovery of some ecosystems when they experience catastrophes, or, as in the pine savannas of Central America, human clearance¹. But rainfall can also damage the plant canopy, either by physical impact² or by leaching elements from the leaves³, both of these processes resulting in decreased productivity, especially if the rainfall is acidic⁴.

There are many well-known examples of precipitation acting as a major source of nutrient capital for a growing ecosystem. Art *et al.*⁵ documented the growth of scrub woodland on a sandy barrier island which is dependent on and limited by the input of nutrients from the oceanic spray and precipitation of the northeastern coast of the United States. Similarly, Chapman⁶ showed that rainfall in Britain provided enough nutrient material (with the possible exception of phosphorus) in a 12-year period to account for the recovery of heathland after regular fire. In both these sites the substrate is sandy and nutrient poor, so that soil reserves are generally low and weathering is not a rich source of new material. Under these circumstances the precipitation input is especially important for the replenishment or growth of the biomass nutrient reserve.

Similar problems are found in the *Pinus caribaea* pine savannas of Central America, recently described by Kellman and Carty¹. These areas were once subjected to fires, but are now managed for forestry, which places the ecosystem under a further nutrient stress as timber is collected from it. Kellman and Carty estimate that the first plantation of pines creates a greater demand for plant macronutrients than can be supplied by the rainfall alone. Considering the first 30 years of growth, they show that sufficient potassium is supplied by rain (3.4 kilograms per hectare per year) to account for the biomass growth, but for calcium only about

60 per cent, for magnesium 30 per cent and for phosphorus 40 per cent of the requirements of the forest are met. Because these data refer to above-ground biomass only, this is undoubtedly an overestimate of the proportions supplied. Clearly the trees are drawing on the soil reserves during the first 30 years of growth. But in subsequent years, as harvests are taken, a steady state of nutrients can be maintained if forest management permits only the extraction of boles while the branches and roots are allowed to rot on site. The nutrient return from this source, coupled with the rainfall input, should account for further forestry needs.

But the passage of rain through a forest canopy can have negative as well as positive effects. Early work by Carlisle, Brown and White⁷ showed that in Britain considerable quantities of nutrients are leached from the canopy by the passage of rainfall, especially in spring and in autumn. The bulk lost in this way is often of a similar order to that contained in the deciduous leaf litter fall. An important further question is whether canopy leaching also results in substantial losses of organic matter, part of the primary productivity of the system. The data of Carlisle *et al.* suggested that it did, but the authors could not separate the effects of aphid secretions of honeydew in their water collections from those of direct leaching.

The new study of Amthor³ directly addresses this problem by analysing data from the Hubbard Brook forest in the United States and from two Himalayan forests. Considering only the summer growing season of the temperate forest and the monsoon period of the Indian forests, Amthor concludes that carbon losses amount to only about 1 per cent of net primary productivity in the temperate site and rather less than that in the tropics. So rain-leaching losses of carbon compounds do not represent a significant proportion of primary productivity.

Yet the detrimental influence of rain, particularly acidic rain, on the overall yield of many plants is now well estab-

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lished Recent data on soybeans⁴, for example, using simulated acid rain, has shown that a reduction in pH from 5.6 to 4.4 can cause an 11 per cent reduction in seed yield for the species. An influential process in the depression of growth may be the destruction of the wax cuticle of leaves by the direct impact of rain droplets, as demonstrated by Baker and Hunt⁵. These workers observe the effects of experimental water droplets travelling at low to medium velocity (0.25–5 metres per second) using scanning electron microscopy and record the stripping of epicuticular wax from the leaves of *Brassica*, *Pisum* and *Eucalyptus*. Such removal of the protective, hydrophobic coat of leaves

could clearly have unpleasant side effects in leaving the plant tissues exposed to pollutant chemicals, pesticides and pathogens. This is the unacceptable face of the soft, refreshing rain. □

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Immunology

The growing immunoglobulin gene superfamily

from Tim Hunkapiller and Leroy Hood

MEMBERSHIP of the immunoglobulin gene superfamily, named for the immunoglobulin light- and heavy-chain gene families, has been growing rapidly in recent years¹. The report by Johnson and Williams on page 74 of this issue² on the gene encoding a rat T-cell-associated antigen adds yet another member to the expanding list. Members of this superfamily all share a common structure called the immunoglobulin homology unit³, a structure composed of a sequence about 100 amino-acid residues long and characterized by a centrally placed disulphide bridge that stabilizes a series of anti-parallel β strands into the so-called antibody fold⁴. The variable (V) and constant (C) homology units, defined for the respective portions of the immunoglobulin chains from which they were identified, have similar but distinct three-dimensional structures. Members of the superfamily extend beyond the immune system and it appears the homology unit has played a central role in the evolution of cell-cell recognition.

The immunoglobulin gene superfamily so far includes eight multigene families and twelve single-gene representatives (see figure). The multigene families include the light (λ , κ)- and heavy-chain gene families of immunoglobulin, the α , β and γ families encoding T-cell receptors and the class I and class II genes of the major histocompatibility complex (MHC)¹. Single-gene members include those encoding T-cell accessory molecules involved in class I (CD8)^{5–7} and class II (CD4)^{8,9} MHC recognition and possibly ion channel formation (T3 δ , T3 ϵ)^{10,11}, a receptor responsible for transporting certain classes of immunoglobulin across mucosal membranes (poly-Ig)¹², β_2 -

microglobulin, which associates with class I molecules¹³, a human plasma protein with unknown function (α 1B-glycoprotein)¹⁴, two molecules of unknown function with a tissue distribution that includes both lymphocytes and neurones (Thy-1, OX-2)^{15,16}, and two brain-specific molecules, N-CAM and neurocytoplasmic protein 3 (NP3)^{17,18}. These widely divergent examples indicate the incredible evolutionary versatility of the immunoglobulin homology unit.

CD8 is a homodimer in humans and a heterodimer in rats and mice (containing the Lyt 2 and Lyt 3 chains). The primary structure of the human CD8 single chain

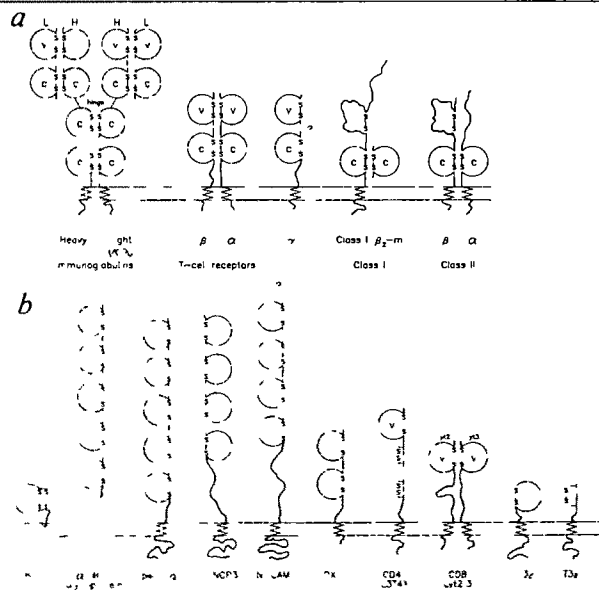
(also denoted T8 or Leu2) and its homologue in mouse (Lyt 2) and rat (OX-8) have been previously determined and found to contain one V homology unit, most like those of light chains, as well as a connecting hinge sequence and trans-membrane and cytoplasmic domains^{5–7}.

In this issue, Johnson and Williams² complete the molecular characterization of rat CD8 with the report of the complementary (c)DNA sequence of the Lyt 3-like chain. This chain also has one V-like homology unit, consistent with the notion that CD8 recognizes conserved determinants of class I molecules with a receptor domain similar to the paired homology unit, antigen-binding domains of immunoglobulin and the T-cell receptor¹⁹.

The Lyt 3-like chain of rat CD8 is distinct from the Lyt 2-like chain in that it also contains a sequence highly homologous to the joining (J) segments of immunoglobulin and the T-cell receptor, particularly those of light-chains. But in contrast, the J sequence of the rat CD8 gene does not rearrange and is encoded by the same exon as the V sequence.

The V sequences of both rat CD8 chains are more similar to light-chain V regions (~30%) than they are to each other (21%). Johnson and Williams suggest that this similarity to both V and J sequences implies that the CD8 genes have descended from genes encoding a heterodimer that existed before the development of gene-segment rearrangement. However, others have suggested that the gene encoding the Lyt 2 chain of CD8 actually is an orphan V-gene segment that lost its ability to rearrange¹. This view is supported by the extremely close linkage of human and mouse CD8 genes with immunoglobulin κ light-chain genes²⁰.

Domain structures of members of the immunoglobulin gene superfamily
a, Molecules of the immunoglobulin gene superfamily that are directly involved in antigen interaction (immunoglobulin, T-cell receptor and MHC class I and class II). The γ chain is included because of its structural similarity to the α and β chains. All these sequences are encoded by multigene families except β_2 -microglobulin, included here because of its interaction with the class I heavy chain. Immunoglobulin homology-unit sequences are represented by circles held by disulphide bonds. Only disulphide bridges present in homology units are indicated.
b, Single-copy members of the family that are not directly involved in antigen interaction. CD4 and T3 δ have disulphide bridges indicated without homology-unit loops. These indicate sequences that may be descended from homology unit structures, but are now significantly divergent.



An intriguing alternative possibility for the evolution of the rat Lyt 3-like gene is that it is the product of an fortuitous *V-J* rearrangement and translocation in a germ cell. If correct, this suggests that the sequences and perhaps even enzymes responsible for the somatic rearrangement of immunoglobulin and T-cell receptor genes can also occasionally generate rearrangements in germ cells and consequently generate new gene combinations. Less similar *J*-like sequences have also been proposed for the *V* homology units of OX-2 and human CD4 (T4)^{16,8}, neither of which rearrange. The suggested *J* sequence of CD4 can be argued against by data that indicate it is split by an intron (J Parnes, personal communication). Interestingly, mouse CD4 (L3T4) may contain another *J*-like sequence elsewhere in the molecule associated with the relic of another *V*-like region⁹. The *J*-like sequences in various single-copy members of the immunoglobulin gene superfamily may represent the product of different evolutionary pathways.

Though originally described as not belonging to the superfamily^{10,11}, re-examination of the δ - and ϵ -subunits of the human T-cell receptor-associated T3 molecule has led to the suggestion that both have a single *V*-like homology unit (A Williams, personal communication). If these similarities prove convincing, it is striking that all the molecules directly associated with T-cell antigen and/or MHC recognition characterized to date (T-cell receptor, CD4, CD8 and T3) are or include members of the immunoglobulin gene superfamily.

A cDNA for α 1B-glycoprotein encodes five internally repeated domains most similar to *V* homology units¹⁴. Its structure is very like the poly-Ig receptor, which also has five tandem, distantly related, immunoglobulin-like domains. Although membrane-bound, poly-Ig has a secretory component and α 1B-glycoprotein may be the secretory component of a membrane-bound precursor¹⁴.

The most intriguing new member of the superfamily is a developmentally regulated neuronal cell-adhesion molecule, N-CAM. Its binding is homophilic (self) and probably polyvalent^{21,22}. The sequence of a partial cDNA isolated from chick embryo brain suggests that like poly-Ig and α 1B-glycoprotein, N-CAM has at least four homology-unit sequences, probably arising from internal duplication. Although described as *V*-like, these units are structurally more similar to *C* homology units. As many as 500 amino-terminal residues of N-CAM remain unknown, leaving the possibility that even more immunoglobulin homology units are present. The homophilic binding function of N-CAM has been mapped to the amino-terminal portion of the molecule along with the homology units²¹. Therefore the homo-

philic and polyvalent nature of N-CAM may result from receptor/ligand binding analogous to the paired homology unit associations that generate the domain structures of other molecules of the superfamily. If true, this finding supports models for the origin of the immunoglobulin superfamily that suggest primordial homology units possibly mediate cell-cell interactions through homophilic associations²³.

N-CAM is a member of a new functional class within the superfamily based on a polydomain structure. Others of this group include α 1B-glycoprotein and poly-Ig receptor; recent analyses suggest that even CD4 is descended from a polydomain precursor⁷. As the CD4 molecule is not known to form dimers, it may interact with class II molecules in a manner similar to the interactions of other polydomain molecules with their ligands, presumably in contrast to the heterodimeric interactions of the CD8 molecule. N-CAM is the first member of the immunoglobulin superfamily that has a brain-specific distribution.

A previously described brain protein, neurocytoplasmic protein 3, has recently been identified as a member of the superfamily (T H, unpublished) and more recent extended analyses of this molecule suggest that it has four homology units (J G Sutcliffe, personal communication). Perhaps, like N-CAM, it functions in cell-cell interactions in the nervous system. Indeed, N-CAM demonstrates that members of the immunoglobulin superfamily can function outside the immune system, thus emphasizing the widespread distribution and versatility of functional charac-

teristics of its members.

Many additional members of the superfamily are surely yet to be identified—the intriguing question is how pervasive will be the usage of immunoglobulin homology units as recognition molecules in mammalian development. □

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Chirality

Distinguishing true chirality from its accidental imitators

from Alexandra J. MacDermott

ONE of the strangest things about the universe is its handedness or chirality. A recent conference* assembled a variety of specialists, from particle physicists to psychologists, to discuss all aspects of chiral symmetry breaking. These ranged from the preponderance among spiral galaxies of rotation to the left with respect to the direction of recession, to the dominance of left cheeks in portraits. But the heart of the debate was the question of why life is based on DNA made of D-sugars and proteins made of L-amino acids, rather than the enantiomeric (mirror-image) L-sugar/D-amino-acid system.

Is the handedness of present-day biochemistry just a frozen accident? Or was it

determined by some chiral influence? Past candidates for the latter have included supposedly chiral combinations such as the Earth's gravitational and magnetic fields, or, more fancifully, asymmetric synthesis by stirring¹. According to L. D. Barron (Glasgow), however, these influences can now be discounted because they are 'falsely chiral'². The hallmark of 'true' chirality is natural optical rotation, which changes sign under space inversion but not under time reversal, that is, it is parity-odd, time-even. Absolute asymmetric synthesis can therefore only be induced by something with this same symmetry. Stirring (parity-even, time-odd) in the Earth's gravitational field (parity-odd, time-even) is therefore no good, as the overall influence is parity-odd, time-odd.

*Chiral symmetry breakings in physics, chemistry and biology, Rouen 17-19 June 1986.